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ABSTRACT

This report focuses on two areas in which the United States has traditionally been a world leader--manufacturing and aircraft maintenance. It shows that both have been affected drastically in recent years by technological change and that both will have to employ highly skilled workers in the coming decade. The report emphasizes the following implications of these changes: (1) workers will need more education; (2) industry should agree on job-skill competencies so that the education system can teach them; (3) students must learn more than just basic skills--they must be able to read well, to think, to make decisions and to work in teams; and (4) workers should have a strong work ethic and be adaptable to change. For each of the two industries, the report summarizes job outlook, education needed, on-the-job training opportunities, competencies, information about some programs that are preparing for the future, worker recruitment, and issues for further exploration. Sources of further information are provided in lists of 12 organizations and 6 publications. Appendixes list the committee members who prepared the report and the members of the National Council on Vocational Education. (KC)

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Occupational Competencies

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National Council on Vocational Education

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Occupational Competencies

A Study of the
Vocational-Technical Education Needs of the
Manufacturing
and
Aviation Maintenance Industries

Conducted by Two Working Groups of

Industrial, Business and Education Representatives

Under the Auspices of

The National Council on Vocational Education

July 1991

Preface

The National Council on Vocational Education deeply appreciates the support and assistance of the individuals who served on the working groups studying the educational requirements for the manufacturing and aviation maintenance industries. Their knowledge and insight made this report possible.

This report will be used by state and local leaders to help in improving the relevance and quality of vocational-technical education programs. It also aspires to establish mutually-beneficial partnerships between business/industry/labor and vocational-technical education. The information from the report should aid students (youth and adults) to understand the career opportunities available in these two industries.

The intense international competition makes it urgent that these industries have a "worldclass workforce." Cooperative efforts and an effective strategy for lifelong learning will be required.

Council Chairman
Bernard Baher

Committee Chairman
Michael R. Farley

Foreword

As we look ahead to the twenty-first century, our country faces many opportunities and challenges. This, of course, is not news. We've been talking for years about challenges, the underlying problems and their solutions. We've been concerned for years about the decline in our country's position in the world marketplace; for example, about our slide from a creditor to a debtor nation, our shift from a manufacturing to a service economy. And we've been warned for years about the inadequacies of our education system, the decline in our students' test scores relative to the scores of students in other countries, and the lack of preparation of our youth for the realities of the workplace.

To be sure, talk and study are necessary forerunners of action. And to be sure, there has been some action. American industry has worked to modernize equipment and processes in an effort to increase productivity and competitiveness. And programs to aid schools and students have sprung up all around the country. Yet our concerns remain. Indeed, in the face of diminishing financial resources, our challenges seem even more daunting...and our time to meet them seems to be running out. The time for actions and results is now.

Unless our country's leaders—leaders in government, education, and private enterprise—choose a course and act on a broad scale to ensure a supply of qualified workers for the jobs that need doing, our country's position in the world marketplace—and, indeed, our economic security—will be seriously jeopardized for the long term. All the efforts to boost productivity, long a goal of American policymakers, could be at risk if we fail to match competent workers with the jobs that keep our economy running.

As we choose a course of action, we must answer some tough questions. Are we, as a country, willing to make substantial changes in education to keep up with other industrialized nations? How should we allocate limited resources? How should business and industry contribute to ensure a qualified workforce that meets future needs? What do we need as a country, and what do we want for our children? Valid cooperation with government, private sector, community and parents are needed to answer these questions and take steps to implement the solutions.

This report focuses on two areas in which America has traditionally been a world leader—manufacturing and aircraft maintenance. Both have been affected drastically in recent years by technological change. Both will need to employ highly skilled workers in the coming decade. And both depend on the education system to produce a workforce well-grounded in the basics, well on the way to technical competence, and prepared to spend a lifetime in retraining as technology and workplaces change.

The report is intended for students and their advisers, vocational-technical educators and administrators, and leaders in business, industry, labor, and government. It addresses

three broad questions: Where are we today? Where do we need to be by the end of the decade? How can we get from where we are to where we need to be?

In preparing the report, we looked at the numbers and types of workers needed in the two fields through the end of the decade, the skills required for entry-level positions, the means of obtaining those skills, and the requirements for career advancement. We also explored ways educators, industry, labor, and government might cooperate to ensure adequate education and training programs for potential and current workers. Along the way, we looked at strategies for recruiting qualified workers.

We chose manufacturing and aircraft maintenance for study and then paired them in a single report, for several reasons. First, workers in both fields need technical expertise that can be provided through vocational-technical education programs. Second, the skills required of workers in these fields have changed dramatically in recent years and will continue to change. Third, the demand for competent, well-trained workers over the next decade is expected to be great; without strong vocational-technical education programs, curricula revisions, and active recruitment, these fields may face severe shortages. Finally, the economic well-being of our country is tied to strong performance in the two fields.

Manufacturing, once a major employer of low-skilled workers, has changed drastically in recent years. New technology, new processes, and new approaches to human resource management have vastly increased demands on workers. Tomorrow's manufacturing environment will require adaptable, multiskilled workers who can operate computers, analyze problems, make decisions, and work cooperatively.

Demands on aircraft maintenance workers are increasing dramatically, as well. U.S. carriers expect to integrate as many as 1,200 new transport aircraft into the commercial fleet over the next six to ten years, requiring maintenance employees to work with new materials and increasingly complex systems. At the same time, standards for maintaining aging aircraft have risen. These increasing demands, combined with an overall growth in the commercial fleet (and in general aviation, as well) mean that many new—and specially trained—aircraft maintenance workers will be needed over the next decade.

The implications of the many changes in manufacturing and aviation are clear: More workers—those new to the field and those retraining or adding skills—will need more education—and much of the burden will fall on vocational-technical institutions. Several consistent themes became apparent as we looked at the vocational-technical education needs of the two industries:

- Educators are asking industry to agree on job-skill competencies required of entry-level workers so curricula reflecting their needs can be written.

- Educators are asking industry to help them stay current on technology and job requirements so they will be qualified to teach students relevant skills.

- Employers are asking educators to teach more than just basic math and language skills. They need graduates with strong skills in oral and written communications who can comprehend technical manuals and write clear instructions and reports. They also need graduates who have strong skills in analytical thinking, problem-solving, decision-making, and working in teams.

- Employers are asking parents and educators to keep an open mind when introducing students to career options—that they not close vocational-technical opportunities to bright, ambitious young people.

- Employers are seeking workers who have a strong work ethic, are reliable, conscientious, and motivated. They also need workers who are adaptable, willing to continue learning as technology changes, and able to contribute as part of a team as work environments become more cooperative.

We hope this report will help facilitate some of the changes necessary to meet the challenges we face as we look ahead to the twenty-first century.

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Introduction

Mandate of the Carl Perkins Act

The National Council on Vocational Education is authorized in Part D of the Carl Perkins Act of 1984 to establish working groups that comprise representatives from industry, business, associations, labor and education to study the occupational competencies needed for selected industries. The purpose of these working groups is to provide the President, the Secretary of Education, members of Congress, and State and local education administrators and advisors with current information on the types and levels of competencies necessary for entry and sustained productive employment in given jobs or industries.

Discussions with these key representatives have provided information about the kinds of employment available to vocational-technical education program graduates, the academic background needed to complete a vocational-technical program, the job skills required, the equipment used in the industry, the facilities required to teach the skills, and the education materials available in the subject area.

The Carl Perkins Act gives the National Council the authority to establish working groups to study the occupations National Council members and staff consider important or necessary. Members of the working groups are appointed by the National Council on the advice of national trade and professional associations, key industry representatives, and labor organizations. Working group members are chosen for their specific knowledge of the technology and practice of the occupations they represent. The results and recommendation of the working groups are disseminated to State Councils on Vocational Education, appropriate state agencies, and local leaders.

Methods and Procedures

The members of the working committees for the manufacturing industry and aviation maintenance met on October 22 and November 13, 1991 in Washington, D.C. During the meetings, the representatives from business, industry and education discussed future occupational competencies needed for the industry, the educational background that will be necessary to prepare students to accomplish those jobs and strategies for attracting young people to careers in the manufacturing and aviation maintenance industries.

Draft reports on each industry which reflected the discussion from the meetings were widely circulated. The comments received from the industry representatives and educators were incorporated into the

final report. A list of all the participants at the October 22 and November 13 meetings, as well as others who made comments on the draft report, are in Appendix I and II.

Summary of the Findings

The working committee concurred that there are numerous, exciting opportunities within the manufacturing and aviation maintenance industries. Because they have become high tech industries, they do require a different type of worker. There must be a higher skill level and an attitude that is receptive to continuous learning and change. Even with higher skills, entry level workers will still need to prove themselves and their ability to move up in the industry.

It was stressed that business will no longer be worker versus management, but a partnership. This fact makes it critical for employees to be able to work with others and accept new responsibilities. Changing technology will make challenges and opportunities great and rewarding for those who develop their potential.

SECTION I:

A Report on the Vocational-Technical Education Needs of the Manufacturing Industry

Imagine yourself in an important new job. You have a great deal of responsibility for how work in your area is accomplished. Together with others on your team, you contribute to decisions about how your work area is run, how budget money is allocated, what equipment you work with, even which agency handles your company's advertising. If you see a problem, you can halt operations in your work area. You and your teammates interview and approve all new team members. One-fifth of your annual salary—and a very good salary it is—depends on how productive your team is, the quality of your work, and company profits.

What is your job? Chief of communications for a major newspaper? Operations manager for a commercial airline? Perhaps assistant coach in the National Football League? Would you ever guess "production worker in an automobile assembly plant?"

As different as this scenario is from the traditional image of manufacturing, it is becoming a reality in many American plants, and will be much more common in the future. Modern factories replaced dreary, unsafe, work environments many years ago. Now, cooperative working arrangements with multiskilled employees involved in decision-making are replacing the strict division of labor so common in the past.

The assembly line established the United States as the world leader in manufacturing. Now changes in the human resources area may help save the American manufacturing industry.

For most of this century, manufacturing has been the chief industry in the United States. In recent years, it has accounted for about one-fifth of the Nation's gross national product and has employed nearly one-fifth of the Nation's workers. Over the last two decades, however, manufacturing in the United States has declined, and American goods have lost their prominence in the world market. Plant closings and layoffs have dominated the news, and a trade imbalance has developed and grown.

The future of American manufacturing is a complex issue. The prospects have been much analyzed and written about. Critics point to outdated equipment and processes, and to an inability to increase quality relative

to goods produced in other countries. Many cite ill-prepared workers and short-sighted management too concerned about short-term profits.

An optimistic view is that American entrepreneurs will invest to increase productivity, American engineers will come up with technological breakthroughs, and with much thought, hard work, and cooperative effort, the United States will regain its competitiveness in the international marketplace. A crucial element in the equation is the American workforce. Can the American education system, together with the manufacturing community, produce the skilled workers essential to the future of the industry?

> ***Wealth creation is what drives a standard of living higher. Virtually all service sector jobs serve three wealth-creating activities—agriculture, mining, and manufacturing—either directly or indirectly. If our standard of living is to be maintained, let alone grow, to keep pace with other economies, wealth must be created.***
>
> **Matthew B. Coffey**
> *President*
> *National Tooling and Machining Association*

Why is Manufacturing Important?

As the position of manufacturing in the U.S. economy has declined, the importance of the services sector—such industries as accounting, finance, insurance, and communications—has grown. Some have suggested that in light of the weakened state of manufacturing, the United States should simply concentrate on providing services and leave manufacturing to other countries. But most observers agree that this would be disastrous and must not be allowed to happen.

Why is manufacturing so important? Because the health of the manufacturing industry has an impact on all aspects of life in our country. At the local level, it affects the standard of living and quality of life of our citizens; at the national level, the economic and defense security of the country; and at the international level, the position of the United States in the world community.

Gene Minton, working group member representing the National Center for Manufacturing Sciences, describes the importance of manufacturing in this way: "The United States can't survive as a national leader unless we have a production base. It's basic economics that the people who have the products to sell are the ones who can make decisions about where they're sold, how they're sold, and how much they're sold for. If we rely on our goods coming from other countries, we're at their mercy in terms of the economics."

The services industry, certainly an important segment of the U.S. economy, simply cannot provide a solid base on its own. Working group member Bill Kurtz, Manager of Industrial Sector Education Strategy for IBM, points out that the service industry relies "not on service for service's sake, but on service from a sound industrial base. As the economy takes a dive, the service industry will go with it."

Even if it were deemed desirable to abandon manufacturing to other countries, it would not be feasible. For one thing, it is unlikely the United States would ever be able to export enough services to pay for all the manufactured products our citizens consume. According to a report by the MIT Commission on Industrial Productivity, *Made in America*, the value of all manufactured goods purchased in the United States in 1987 totaled about $1 trillion, nearly twenty times the value of services exported. Moreover, it is likely that as manufacturing firms move to other countries, companies that provide services to those firms would follow.

A final argument for the need for a strong manufacturing base, and perhaps the most compelling, is its importance to national security. As the MIT study pointed out, the U.S. Department of Defense "depends on virtually every sector of the [U.S.]

manufacturing base for its matériel. *For the nation to become heavily dependent on foreign technology for its defense would be politically and militarily untenable* [italics added]."

A Varied Industry

Manufacturing encompasses a wide range of products, from delicate precision instruments to large construction equipment. Manufactured products often are categorized as light or heavy; durable (long-lasting, such as a home heating unit); or nondurable (used up quickly, such as a loaf of bread); and consumer goods (sold in retail stores, for example, clothing); or producer goods (used to make other products, for example, steel). Some of the leading manufactured products in the United States in recent years have been transportation equipment, food products, chemicals, electric and nonelectric machinery, printed materials, fabricated metal products, scientific instruments, and paper products.

There are about 358,000 manufacturing firms in the United States. Approximately one-third of them have at least 20 employees. These firms operate large factories, tend to have traditional corporate structures, and manufacture such goods as textiles, printed and metal products, and machinery. The remaining two-thirds are small companies that have fewer than 20 employees. They tend to have less formal corporate structures and to manufacture specialty products such as furniture and health aids.

The manufacturing industry workforce includes far more than assembly-line workers and machine operators. Also involved in the industry are managers, who provide direction for the company; engineers and technicians, who create and test new products and processes; systems analysts and information processors, who provide information on which to base decisions; financial analysts and accountants; human resource specialists; distribution and sales personnel; and administrative and support personnel.

In 1988, 19.4 million Americans were employed in manufacturing. Most of them were operators, fabricators, and laborers. The next largest group were involved in precision production, craft, and repair. A large percent of manufacturing establishments are small companies. (Refer to Chart 1).

Traditionally, large manufacturing companies have been located near large cities. In 1986, the leading manufacturing states were California (Los Angeles-Long Beach; San Francisco-Oakland), New York (New York City; Rochester), Ohio (Cleveland), Illinois (Chicago), Michigan (Detroit), Texas (Houston; Dallas-Fort Worth), Pennsylvania (Philadelphia), North Carolina, and New Jersey (Newark). Other important manufacturing centers were Boston, St. Louis, Milwaukee, and Baltimore.

Short-Term Outlook for Manufacturing

Despite indisputable evidence of an overall decline in manufacturing in the United States, there are also reasons for optimism. For one thing, exports of manufactured products are up, and that rise is expected to continue through the end of the century. Domestic demand for many U.S.-made products also is expected to grow. Many American firms continue to manufacture quality products, updating their methods and practices as needed to remain competitive. Others are instituting changes to make their products more attractive at home and abroad. Even the recent focus on the problems of American manufacturing holds out hope that change will be forthcoming.

Some segments of the manufacturing industry are expected to remain strong, or even grow, through the end of the century. The fastest growing segment will be computers and related products. Other goods expected to show strong growth are health care and food products. Expected to show modest but steady growth are the heavy machinery, primary and fabricated metal, and motor vehicle industries.

Growth (or decline) in manufacturing output does not necessarily translate into growth (or decline) in labor force needs. Although manufacturing output is expected to increase over the next decade, the total number of jobs in the industry will decline. In several areas, however, the number of jobs will increase. Employment in computer

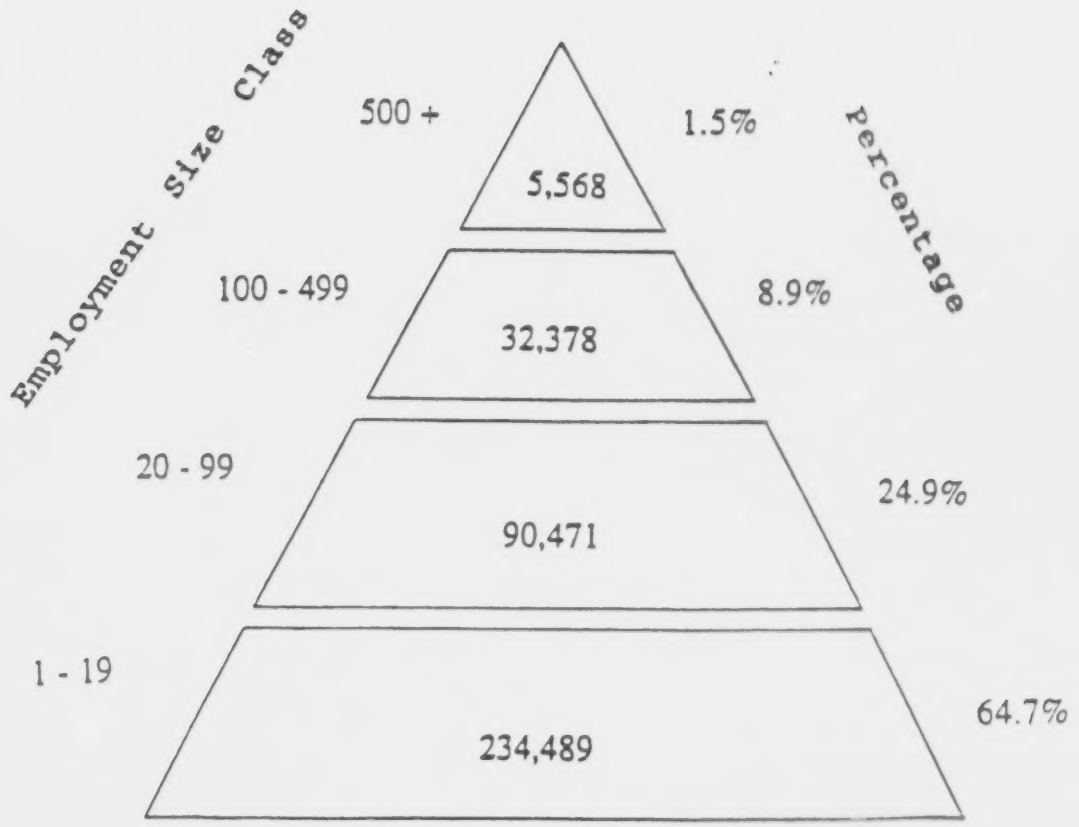

Chart 1.—U.S. Manufacturing Establishments (SIC 20 - 39) Total: 362,906. Source: U.S. Bureau of the Census, 1988; figures published December 1990; the National Coalition for Advanced Manufacturing.

equipment manufacturing will increase substantially, as will employment in manufacturing related to health care and in the printing and publishing sector.

A Promising Career Choice?

With all the analyses and projections, it is easy to become confused about the prospects of the manufacturing industry as a career. The bottom-line question for students and their advisers remains: Is manufacturing a good career choice? The answer is a qualified "yes." For one thing, many jobs are available in manufacturing—19.4 million in 1988, accounting for nearly one-fifth of the Nation's workforce. While that number will decrease over the next decade (by as many as 300,000 by the end of the century), the decrease will be mostly in the area of unskilled labor. The need for certain kinds of workers, particularly in certain sectors of the industry, will grow markedly. In addition, many current workers will retire and need to be replaced. As the workforce continues to age through the end of the century, there will be fewer young people to replace these retirees.

Also to be considered is the increasing number of foreign companies building manufacturing plants in the United States. These companies need skilled employees. Some have even brought in skilled workers from other countries because they are unable to hire enough U.S. workers to meet their needs.

Most of the new jobs in the manufacturing industry will require some education and specialized training beyond high school; many will require a considerable amount of additional education. No longer will the industry need large numbers of unskilled and low-skilled operators and laborers. Gains will be in the technician and related support occupations, the professional specialty

occupations, the executive, administrative, and managerial occupations, and the marketing and sales occupations. The tooling and machining industry's needs for workers may increase annually over the next ten years by at least 5 percent. Growth industrywide is likely to be in smaller companies.

At the personal level, this means that jobs in manufacturing will be available for individuals who have a sound academic foundation and the specialized skills needed by one of the many manufacturing industry groups. In fact, it may be a "seller's market" for those who are well prepared and are willing to continue their education as technology and the markets change. And because skills will be broader based and related to technologies rather than specific processes, workers will have greater opportunities to move from company to company and from one type of industry to another.

Why a Career in Manufacturing?

Manufacturing encompasses a wide range of occupations, a wide variety of products, and widely differing work environments. Some jobs are high-tech, and some are mid-tech. The settings range from clean rooms (in many cases several orders of magnitude cleaner than hospital operating rooms) where silicon is turned into integrated circuits; to huge assembly plants where thirty or more commercial airliners are in some stage of assembly; to small machine shops, where workers operate computerized equipment to produce parts. There is an occupation, a product, and a work environment to match nearly every interest. And common to each industry group are characteristics that make it an exciting career choice.

Manufacturing offers the pride that comes from creating something. It is challenging and allows people a chance to use their minds. It can be fun. It pays well. It provides an opportunity, given the right set of circumstances, to change what is being done. And it gives one a sense of ownership "because that part of the manufacturing process belongs to you."

Working group member Camiel Thorrez, president of a firm that manufactures automobile parts, notes that although some segments of the industry (aerospace, for example) might be considered glamorous, that is not where the satisfaction lies. "The 'glamorous' thing," he says, "is that by the time you're done, you've made something work, and you keep something working. You're in charge of your whole area—the quality, the cleanliness, the equipment, and manufacturing the product—the whole range."

Manufacturing is an exciting career for those who want to apply knowledge, are resourceful, and get satisfaction from seeing tangible results for their efforts.

The New Manufacturing Environment

It may come as a surprise that individuals who are resourceful could be happy in the manufacturing industry, given the image of manufacturing occupations as made up of discrete tasks narrowly defined and relatively easy to learn.

Manufacturing has changed vastly in recent years. Working group member John Lapolla, Manager of the Chrysler Training Support Group for RWD Technologies, describes changes in one industry from personal experience: "Back in 1970, when I started in an automotive assembly plant, it was not a place where you'd want to work. It was relatively low-tech, and the floor worker's job was very mundane. In twenty years, we've become very high-tech. It's now a team environment, and a lot more responsibility is placed on the floor worker." Adds another working group member: "It used to take about thirty minutes to train a worker on the floor to take a part from one place and put it in another. Now the more progressive companies have started asking people to do the thinking on the production floor and to solve problems."

Companies are going to look even more different ten years from now. Management is recognizing that the wealth is produced on the factory floor. "The forward-looking companies are going to be highly flexible,"

> ***[In the future] there will be increased opportunities for individual workers, through personal ownership and leadership of their own activities, to receive increased pay, recognition, responsibility, and authority.***
>
> **Bill Long**
> *Manager of Human Resources*
> *Texas Instruments*

says one working group member. "They're going to have workers involved in decisionmaking on the factory floor." Working group member Bill Long, Manager of Human Resources Development with Texas Instruments, cites self-managed work teams and cell teams responsible for everything with which they come in contact. They will decide who does what. The best teams will provide input on pay.

Organizations also will change structurally, becoming flatter, with fewer managers. Says working group member Minton: "It's going to be easier for workers to be involved in decisionmaking than it has been in the past. The opportunity is going to be there because there will be fewer mid-level managers."

Manufacturing Workers of the Future

Given the vast changes in technology, processes, and environments, workers in tomorrow's manufacturing plants will need far different skills than those in the past. Moreover, they will need to be multiskilled, able to perform a variety of tasks and to understand how their work fits into the overall process.

Job Abilities

Tomorrow's manufacturing jobs will place great demands on workers' knowledge, their communications skills, and their willingness to continue learning throughout their careers.

- **Knowledge of computers.** Workers will be expected to design, develop, manufacture, program, set up, operate, and maintain advanced equipment systems. On top of a sound academic base (described in the next section), many (if not most) will need knowledge of computers and computer systems, including such procedures as computer-aided design and manufacturing (CAD/CAM), computer numerical control (CNC), and statistical process control (SPC). Many will need specialized knowledge for their particular industry segment and position (for example, electronics, machining), specialized materials (for example, composites or metallurgy).

- **Communications skills.** Tomorrow's workers will have to be able to communicate well, both orally and in writing. As part of a team, they will need to be able to express their ideas (for example, to describe how a procedure should be done or the benefits of doing a task a particular way). Just as important, they will need to be effective listeners, able to understand a fellow worker's idea or problem.

- **Thinking skills.** Tomorrow's manufacturing workers will need analytical and synthesizing skills. Because they will have far more responsibility in their jobs, they will be expected to think, reason, and solve problems. They will have to be able to troubleshoot and repair complex equipment and to take an idea and integrate it with someone else's idea.

- **Interpersonal skills.** In manufacturing plants of the future, the team approach will be stressed. Good interpersonal relations, including a spirit of cooperation, willingness to share and accept ideas, and respect for the ideas and work of others will be essential.

- **Commitment to lifelong learning.** Rapidly changing technologies and processes will require all those working in the manufacturing industry to continue to learn throughout their careers.

Personal Qualities

Positive work attitudes and good work habits also are essential to individual success in manufacturing. Such fundamental work ethics as reliable attendance, promptness, and good personal grooming are all important. The importance of hard work and dedication cannot be overemphasized. Individuals need to recognize that pay is a reward for performance, not an entitlement.

In the manufacturing industry, as in other fields, the personal qualities of employees also have a direct bearing on company success, which in turn affects individual success. As American manufacturing works to regain its position in the world marketplace, pride of workmanship and commitment to quality take on even greater importance. The growing number of multinational companies and American manufacturing's involvement in global markets also have implications for future workers. They will have to be flexible, able to adjust to rapidly changing job descriptions and customer demands, and even to assignments in foreign countries.

The following list of personal qualities important for workers in the industry was drawn, in part, from a checklist used by Res Manufacturing, a producer of metal products located in Milwaukee, to evaluate new employees:

- **Values**
  - Is honest in dealings with employer and fellow employees
  - Takes pride in work and product
  - Takes responsibility for own actions
  - Is consistent in behavior (no abrupt changes in mood)
- **Work habits**
  - Is able to work with a minimum of supervision
  - Looks for constructive things to do when the primary job is not functioning
  - Maintains good attendance record
  - Practices safe work procedures
  - Has good organizational skills
  - Practices good housekeeping habits
- **Commitment to quality**
  - Strives for excellence in work and product
  - Strives for continuous improvement
  - Is aware of customer needs and tries to fulfill them in every way possible
- **Personal traits**
  - Is neat in appearance
  - Uses common sense and logic in performing day-to-day duties
  - Demonstrates drive for achievement
  - Is curious
  - Is self-confident
  - Is flexible and adaptable; is willing to learn new jobs, cross-train for a variety of jobs, and work extra hours in times of high customer demand

Education for Future Workers

Secondary Education

Tomorrow's manufacturing employees will need a solid background in English, math, physical science (chemistry and physics), and computer literacy. They will need to read at a 10th to 12th grade level and be able to express themselves effectively, both orally and in writing. All will need basic math, through algebra; many jobs will require higher math skills, especially geometry and trigonometry.

This basic background may come through traditional academic courses, or through applied "hands-on" courses (for example, applied math). Courses emphasizing technical writing and technical English (for example, interpreting technical writing such as instruction manuals) can be especially helpful. In most cases, these basic skills will merely provide the groundwork for more specialized knowledge and skills needed in the various industry groups (for example, electronics, mechanical design, machining, metallurgy, and print reading).

A high school education or equivalent will be the *minimum* requirement for tomorrow's manufacturing workers. This basic education can be obtained within a

straight academic program, or in a combined vocational-academic program—a school-based cooperative education program, for example.

Some schools are recognizing an additional type of secondary education, one that draws from both the "academic" and "vocational" fields—technical education, or "tech prep." These programs provide basic and specialized education with a slant toward technology. Coursework may include applied mathematics, science, and communications and principles of technology—plus a focus on technology clusters (for example, electronics or hydraulics), or on skills and work-based learning (for example, machining or welding), depending on whether the student plans to continue his/her education or enter the workforce after high school graduation. Tech-prep education provides excellent initial preparation for a career in manufacturing.

Postsecondary Education

The majority of jobs in the next decade will not require a bachelor's degree, but they will require additional education and training beyond high school. This additional education may be obtained in a technical school or community college and may come within a formal structured program or through a selection of individual courses. Advanced courses may be generally applicable to the manufacturing industry (for example, advanced computer science, quality principles, and basic statistical process control) or may be specialized courses necessary in a particular industry group (for example, material science, engineering graphics, or metal cutting).

"2+2" and "2+2+2" Programs

An arrangement that is becoming more common is a program that stretches from the junior year of high school through coursework and occupational education in a two-year college program (a "2+2" program)—and in some cases through a final two years at a four-year university (a "2+2+2" program). These programs may start with a tech-prep program in high school, with students taking applied academic courses, principles of technology, and courses focused on a technology cluster (for example, electronics). Students then enroll in an associate program in such areas as manufacturing or lasers/optics at a community, technical, or junior college. From there, they may go on for a bachelor's degree in advanced technology or a related field at a four-year university.

Apprenticeships

Another highly desirable option for preparing for employment in the manufacturing industry is a formal apprenticeship (for example, in precision metalworking). Apprenticeships, which are arranged through specific employers, provide an apprentice with closely supervised on-the-job training supplemented by related classroom instruction. The related instruction may be provided in-house (at the employment site), or may be gained at a community college, in adult education classes at a local high school, or through correspondence courses. The length of an apprenticeship varies with occupation and industry and may be two to five years.

Hybrid Programs

Some programs may combine features of apprenticeships and "2+2" programs. Such hybrid programs are four-year, work-based programs in which students, at the beginning of their junior year of high school, enter into a contract with an employer. They lead to a high school diploma and college credit (and possibly an associate degree). The instruction, which takes place chiefly in the work setting, combines academic, technical, and occupational training.

On-the-Job Training

Workers at all levels in the manufacturing industry can expect to participate in a considerable amount of on-the-job training. The amount will depend to great extent on the industry group and the goals of the training.

To become highly skilled workers capable of advancement and of functioning in several areas in an organization, *entry level employees*

coming to work with no formal training might participate in a broad program combining manufacturing skills with technical college courses, leading to a specialty in a specific process. Such comprehensive programs might run as long as three to five years. Training for a limited specific function would be far shorter.

On-the-job training for *mid-level employees* is more specialized. The amount and focus may vary with needs or may be planned and on-going as an employee progresses on the job. The purpose of training may be to enhance the employee's skills, to bring the employee up-to-date on new technology, or to introduce new concepts. Mid-level employees not already familiar with such procedures might receive training in computer-aided design (CAD), statistical process control (SPC), Just-in-Time (JIT) inventory control, computer numerical control (CNC), and computer-integrated manufacturing (CIM).

Supervisory level employees might receive on-the-job training in management and supervisory skills, such as team-building and interpersonal relations. Short courses or seminars (one or two weeks) conducted off-site may suffice. Supervisors also will need to keep up-to-date on new technologies and processes.

Testing Competencies of Employees

In some employment areas, tests are used to determine whether "students" have acquired a certain skill or knowledge. Those who demonstrate competence by passing the test are allowed to move on to the next higher level of education or training or the next job category. They may be awarded a license or some other certification of their competence. In some fields (aircraft maintenance, for example), licensing is regulated by a government agency or a professional association.

Likewise, competency is the basis for formal programs of education and training in some occupations. Rather than study a subject or skill for a predetermined amount of time, students advance to the next level as soon as they demonstrate competence at the lower level.

Competency testing is not widely used in the manufacturing industry. One reason may be that there are few consistent benchmarks or reference points, and it is nearly impossible to identify all the requirements of a job. Nor has competency-based instruction been common in the past (possibly because many companies have not had personnel who have a background in the kind of self-paced instruction necessary for building competency-based instruction and testing). It is, however, becoming much more common, both in schools and in places of employment.

A panel of representatives from the business, education/training, and testing communities currently (1990) is being formed to address the issue of competency testing of skills needed in manufacturing occupations. The group will look at the possibility of identifying industry standards from an educational and skill-level standpoint.

The lack of strictly defined competencies does not mean that competency is not an important issue in the manufacturing industry. Competencies in many manufacturing industry groups have been identified on an informal basis. These include knowledge of materials, cutting and forming processes, mechanisms, machines, measurement, and control. Competency is tested informally, on a continuing basis. Regulation is informal through quality control of the product and supervision of performance.

The National Tooling and Machining Association (NTMA) has identified some predictors of success and has developed an aptitude test to aid in screening potential metalworkers. Secondary and postsecondary school systems and individual employers use the NTMA Aptitude Testing Service.

Lifelong Learning

Perhaps more than in any other industry, employees in the manufacturing industry must keep abreast of new technology, new equipment, and research relative to the field. In fact, things change so rapidly over a career that time for continuing education increasingly may be designed into an employee-development program. Workers may seek out the training on their own, for

We have to make sure each individual who chooses to go into manufacturing understands that it's going to be a continuous learning process.

Sandra Everett
Program Developer
Industrial Technologies Division
Lorain County (OH) Community College
Advanced Technology Center

their own advancement, or the training may be sponsored by their employer. Continuing education is widely available, from a variety of sources.

Suppliers of manufacturing equipment provide training in programming, setting up, operating, and maintaining their equipment. The courses may be included in the purchase price, or they may be purchased and provided for employees as necessary after the equipment is in operation.

National professional and trade associations also provide materials for continuing education and sometimes the instruction itself. The National Tooling and Machining Association (NTMA), for example, has developed a curriculum called Metalworking Training System (MTS) that includes lesson plans, texts, visuals, and quizzes. The 320 curriculum modules, which together constitute a four-year apprenticeship program, cover such topics as blueprint reading, computer numerical control, basic machines, and intermediate machining technology. All or some of the modules can be purchased by educators and industry for use in secondary and postsecondary schools and in work settings. The Society of Manufacturing Engineers (SME) offers a wide variety of courses and seminars, primarily for managers and upper level technicians, covering all aspects of manufacturing technology. SME also maintains a library of technical literature and video courses that may be purchased or rented.

In addition, local affiliates of national associations may offer continuing education for specific industry groups, either independently or in cooperation with local schools.

Technical schools are another source of continuing education, as are institutions of higher education. Community colleges are an especially good source, as they tend to be flexible and can respond quickly to the needs of the community.

Meeting Future Labor Needs

The future of the manufacturing industry rests in large part on the quality of its workforce—the education and skills of employees, their ability to think and reason, their adaptability, and their commitment to quality. How will the industry meet its future labor needs? The answer lies in a number of areas: the size, composition, and qualifications of the labor pool, and the industry's ability to recruit and retain qualified workers.

Source of Workers

According to the Bureau of Labor Statistics, through the end of the century the U.S. labor force will grow about 1.2 percent annually (a much slower rate than during the preceding twelve years). This represents a net increase of 19 million workers.

The fastest growing segments of the labor pool will be Hispanics, Asians and others (including Asians, American Indians, Alaskan Natives, and Pacific Islanders), blacks, and women, as shown in Table 1.

Table 1

	Projected annual growth in labor force participation, 1988-2000	Projected percentage of labor force, 2000	Projected increase in percentage of labor force, 1988-2000
Hispanics	4.0%	10%	3%
Asians and other workers	3.6%	4%	1%
Blacks	1.9%	12%	1%
Women	1.7%	47%	2%

Whites, including Hispanics, will show a 14 percent cumulative growth over the period 1988-2000, making up 84 percent of the labor force in 2000, down 2 percent from 1988. (If Hispanics are excluded, whites would constitute 74 percent of the labor force in 2000.)

The teenage labor pool is expected to shrink until 1992, then grow over the rest of the decade.

These projections for labor-force size and makeup, when taken together with projected changing needs in the manufacturing industry and data on education and literacy, have important implications for the manufacturing industry. First, it appears that in the future, a greater percentage of the manufacturing workforce will come from women and minorities. More critical, over the period 1988-2000, the occupational groups likely to have the fastest growth are those requiring the most education and training, while the occupational groups likely to have the slowest rate of growth (or decline) are those requiring the least education and training. Yet the groups in the workforce growing most rapidly show a lack of educational achievement.

The problems of public education in the United States are well documented. Many manufacturing companies have become involved in public education through the local schools, and others are providing basic education for current or potential employees. However useful this involvement may be on a local level, it is clear that the industry faces a tough task in filling the more demanding jobs of the future from a shrinking pool of well-educated high school graduates.

Of course, recent high school graduates are not the only pool of potential workers for the industry. Working group member Rolland Westra, Director of the Rock Valley College Technology Center (Rockford, Ill.), suggests that "perhaps the greatest untapped potential resource is the untrained potential of the existing workforce."

Recruitment of Workers

Recruitment of qualified young people to the industry is critical to the future of manufacturing in the United States. In turn, recruitment depends in large part on (1) familiarizing youth, their parents, and school advisers with the many opportunities in the industry and (2) enhancing the industry's image and stature.

With some creativity and investment of time and money, the first task may be relatively easy to accomplish. The second is more formidable. Those who attempt it must work against several strongly held perceptions. One is the image of manufacturing as it once was, a place where a worker was taught one task and was replaced rather than retrained when a new task was required. Not surprisingly, the notion persists that jobs in manufacturing are for those who have few skills and little ambition. An even more difficult problem may be overcoming the negative publicity of the plant closings and employee layoffs of recent years. Finally, there is the perception in our society (perpetuated in some schools) that anything less than a four-year college education means secondary status—despite the fact that by the year 2000, more than 70 percent of jobs will not require a college education.

The misunderstanding and negative perception of manufacturing often plays out in school practices regarding vocational education. The reality is that the industry needs bright, multiskilled workers (for example, metalworking firms need individuals who have strong aptitudes in math, computers, metallurgy, and spatial relations). Yet in some schools, vocational education has been a neglected afterthought, a dumping ground for uninspired students and troublemakers and certainly not an appropriate curriculum for the academically oriented.

■ Recruitment of Young People

Efforts to interest young people in manufacturing careers must begin in elementary school. Children are never too young to experience the pleasure and pride that comes from creating something. On that experience can be built an understanding of the nature and importance of manufacturing, and the career possibilities it offers.

Teachers and counselors who provide information on careers and guide course selection are a critical element in the effort to familiarize students with career

opportunities. They need information on the industry as it is today and is expected to become in the future. They need to know that the opportunities and the settings are varied and to understand what kinds of students can thrive in today's mid-tech and high-tech environments. Teachers and counselors also need to be made aware of the secondary and postsecondary education programs that help prepare students for these careers. Finally, they need information on the earnings potential of manufacturing occupations (often surprisingly high, as much as 20 percent higher than other occupations according to one estimate).

Much of the burden for recruiting young people rests on the industry itself. For a start, the industry might encourage a change in terminology to reflect the nature of work in manufacturing. To some, the term "vocational education" suggests manual training. By identifying careers that require specialized postsecondary education short of a four-year college degree and applying a new term (for example, "mid-tech") to them, the industry could differentiate the new opportunities from the old image of vocational training for less demanding work.

Beyond that, local manufacturers need to open their doors and encourage frequent visits (student field trips and public open houses, for example), so students, educators, and the community can see what goes on there. They might sponsor a local, regional, or national Manufacturing Industry Day to "showcase" the industry; prepare exhibitions (or demonstrations) for community events or public spaces (libraries, for example); or initiate and support museum exhibits of art, tools, and machines that focus on humankind's efforts to create goods.

Manufacturers should seek opportunities to visit schools and talk to students about the career opportunities in their industry group. They might speak from personal experience about the satisfaction and excitement they have found in the field; use visual materials, even sample materials and finished products, to give young people a vision of what manufacturing is all about; and point out the linkage between academic courses (particularly math and science) and the world of work.

Current employees should be enlisted to become involved in the school-level recruitment effort (when possible, graduates might return to their old schools). Research indicates that manufacturing workers generally are satisfied with their career choice. Their knowledge of job requirements and advantages could be invaluable in recruitment activities.

Manufacturers should make certain printed materials (for example, eye-catching posters) describing career opportunities, both generally and locally, are available (and in use) in local schools and libraries. The materials should address education requirements, salary potential, and other relevant topics. The starting point might be actual classified ads that have been run recently, with the advertised jobs tied to specific career preparation. When the materials are designed, suggestions as to what information would be useful and what format would be appealing might be solicited from counselors, students, and even recent entry-level employees.

Manufacturers might also consider developing a video for viewing by students. This might be done jointly with others in the local area or region. For example, the Frank Paxton Company, a supplier of hardwood lumber products in Kansas City, and its subsidiaries have sponsored creation of a video, "You Can Do It," about the importance of developing skills in thinking and in using tools. The video is designed to encourage interest in industrial arts, vocational education, and technology education among middle school students.

To help educators (counselors, and math and science teachers, for example) become familiar with the field, manufacturers need to get those people onto the shop floor. Because educators are often strapped for time and most school budgets do not provide for such information-gathering opportunities, manufacturers might sponsor paid summer internships for teachers. These teachers could then educate others in their schools.

Recruitment efforts need not be limited to large businesses that have the resources to, for example, sponsor teacher internships. Small businesses might adapt a program initiated by a Michigan manufacturer whose workforce is about 200. The children of

employees are invited to spend a day at the workplace. In the morning, they tour the entire operation; in the afternoon, they "shadow" their parents, working alongside them.

Activities that recognize exceptional skills or the contributions of individuals or employee groups can garner publicity and enhance the stature of the industry. For the long term, the industry might consider renewing the "master craftsman" concept. For now, manufacturers might work together to institute awards on a local or regional level.

Trade and professional associations can do much to promote careers in their industry group. The National Tooling and Machining Association, for example, has developed an aggressive, integrated plan to attract talented people to that industry. The plan identifies specific target groups and then lays out a comprehensive strategy for getting the message out to the target groups through the schools and the media. Tasks for the national association (develop and provide resources) and local chapters (plan implementation) are specified, and a system for monitoring plan effectiveness is outlined. The NTMA also has developed a film, "Go For It," about jobs and careers in that industry, and conducts an annual national competition for fourth-year apprentices to help publicize career opportunities.

On a broader scale, the Vocational Industrial Clubs of America, a nationwide partnership between business/industry and secondary/postsecondary vocational students and instructors, sponsors annual student competitions on the local, state, and national levels. The national competition, known as the United States Skill Olympics, includes contests in such areas as electronics technology and precision machining. U.S. winners are selected to compete internationally.

■ Recruitment of Mature Workers

Current secondary students are not the only potential source of workers for the manufacturing industry. Mature workers who have not had formal training since high school and/or are working in other fields are another possibility. It is not unusual for individuals to enter the field several years after high school graduation. Although general publicity campaigns may reach this group, a separate recruitment strategy might be even more effective.

The National Tooling and Machining Association's recruitment plan targets such groups as auto racing fans, model airplane hobbyists and partly skilled workers displaced from other industries. Two local Tool and Machining Associations (TMA's) (which are independent from the NTMA) are actively recruiting such mature workers. The Chicago TMA had a talk show with the Governor of Illinois about tooling and machining that led to 300 inquiries. And the TMA in Dayton is developing a 30-second television commercial to be broadcast during Monday night football games.

■ Words of Caution

In developing a recruitment plan, manufacturers should make certain their efforts are aimed at the right people, for the right reasons. One working group member, who says his company is only secondarily concerned with hiring trained employees and in fact prefers to do the bulk of the training itself, points up the reason for this caution: "The thing we'd like is someone coming to us because they *want* to, not just because they *have* to." The other point of caution is making certain not to overstate the case. The promised career opportunities must be real.

Retention of Current Workers

Retention of workers in the manufacturing industry is not generally viewed as a problem. A recent study in Massachusetts found that 78 percent of employees and supervisors in metalworking machining wanted to remain in the trade.

For entering workers, thorough training and the prospect of a career path and job security should ensure retention. For older workers, retraining for more highly skilled jobs should result in higher pay and more contentment. Given these best case scenarios, worker retention may be a function of the company culture and management ethics.

Cooperative Efforts to Prepare Workers

Business, industry, labor organization, and educational institutions, acting cooperatively, can do much to prepare workers for employment in the manufacturing industry. The first task is to establish closer relationships at all levels—local, regional, state, and national—through structured communications and support networks.

Business and industry need to tell educators what they want and expect from graduates, and the groups together need to determine what is now lacking. Working group member Westra believes lack of definition of required job skills, and lack of definition of education needs are serious obstacles.

In defining needs, leaders might take note of the work of SCANS (Secretary's Commission on Achieving Necessary Skills) in the U.S. Department of Labor. SCANS is first identifying skills needed for success in the workplace and then determining whether these skills are teachable and assessable and how such information should be disseminated. Although the study addresses all types of work, the conclusions may be modifiable for work in manufacturing. An initial report is expected in May 1991.

Once needs have been identified, industry, labor, and education should jointly design education programs and curricula in technology and specific occupations, as well as multicraft crosstraining programs. Some of the materials might be in the form of computer-aided coursework and videos. A special effort should be made to provide classroom programs attuned to the needs of local industries.

The groups also need to develop programs that get educators into plants so they can gain an understanding of what takes place on a plant floor and what skills and traits workers need.

The education and manufacturing communities should look at ways they can share resources (people, equipment, facilities, and knowledge). They should also explore ways to increase education's role in in-plant, applied research.

Manufacturers, labor organizations, and educational institutions also can do much in the area of informal programs to prepare workers. Groups involved in manufacturing can open their workplaces to field trips, supply videos on various specialties, and even adopt a school. Educators can invite manufacturers into the schools to serve as guest lecturers, advising students on career opportunities in industry and describing the applications of math, science, and other academic courses to real-world work situations.

As the various communities cooperate to prepare workers for the manufacturing industry, they should keep in mind that their efforts need to extend down into the lower grades. Perceptions of the world of work begin to form at a very young age, as do attitudes about the applicability of academic learning to the real world. Manufacturers can encourage and support educators' efforts to develop elementary-level curricula that explore occupations and enhance thinking, problem-solving, and teamwork skills. They can also help get computer equipment and computer literacy programs into the schools. Further, specific preparation for careers in technical fields must begin before late high school. As one working group member points out, "There are a lot of marriages between industry and technical schools now. We need to get it down to high schools and junior high schools. We have to get students by seventh grade, or we've lost them."

Programs to Prepare Workers

Education and training programs for potential and current workers are abundant. They have been set up by local schools and school districts, community colleges, government agencies, and industry groups to serve local areas, regions, and states. Some are single-agency efforts, and others are cooperative efforts. The programs described here are not necessarily representative of the types of programs available, and the list is by no means exhaustive. Instead, it is a sampling of what is being done to prepare potential employees and to keep current employees' skills up-to-date:

- **A consortium of state directors of vocational education** has directed development of materials that emphasize academic content in the context of hands-on, applications-oriented instruction, for use primarily in secondary vocational programs but also useful in postsecondary adult training programs. Developed (or being developed) by the Center for Occupational Research (CORD) and the Agency for Instructional Technology (AIT), the courses cover Applied Mathematics, Applied Biology/Chemistry, Applied Communication, and Principles of Technology. The materials can be integrated with vocational courses or taught alone as credit courses by either academic or vocational instructors.

- **The Bevill Center for Advanced Manufacturing Technology** (Gadsden, AL) is working with three local school systems and other groups to develop a tech-prep program for grades 9-12. All students—those who plan on post-secondary education (both two- and four-year degrees) and those who expect to enter the workforce immediately after graduation—must take at least one year of principles of technology, and all may enroll in technical courses. Those who wish may concentrate in one of several areas (for example, electronics, electricity, or industrial maintenance technology). The program is articulated with the local community college (a "4+2" program), and students may be eligible for credit toward A.A.S. degrees in such areas as electronics engineering technology, machine technology, and mechanical design technology.

- In September 1991, the **Commonwealth of Pennsylvania** will begin a work-based-learning demonstration project, the Pennsylvania Youth Apprenticeship Program, in four regions around the state. The four-year program, which will focus on metalworking trades, will combine academic, vocational, and employment education for students who have completed tenth grade. Apprentices will be paid a wage for all four years of the program. They will finish with a high school diploma and up to two years of college credit.

- **Several entities in Massachusetts**—a private industry council, a labor council, a county employment and labor consortium, and several local labor unions—worked together to form the Machine Action Project (MAP). Supported by the Commonwealth, MAP, among other things, works with employers, education/training institutions, and community groups to improve the quality of training programs in several fields (including machining), develop a more coordinated delivery program, and more fully involve industry in the way programs are designed and taught.

- **Focus: HOPE** (a Detroit nonprofit civic organization led by Executive Director Father William T. Cunningham) trains minority youth and others in manufacturing technology. It provides a sequence of three programs—a six-week school-to-work transition program to upgrade basic skills, an eight-month classroom and hands-on program in precision machining, and a six-year program of structured work experience and classroom study in applied engineering to produce technician-engineers able to work on advanced manufacturing equipment.

- **Transformations**, a model program in training for technology (developed by Sandra Everett, Program Developer at Lorain County Community College in Elyria, Ohio, and the Center for Occupational Research and Development in Waco, Texas) combines broad-based education with training in computer skills and in a technical skill focused on a career. The 18-week program, originally designed for displaced workers, now is available for college credit. It can be adapted for use with the current workforce.

- **The Robert Bosch Corporation** (a producer of fuel pumps, fuel injectors, and antilock braking systems in Charleston, South Carolina) provides 126 hours of structured preemployment training for production jobs to approximately 145 potential employees annually. The course covers company

history, blueprint reading, quality, and nine other subjects. Bosch also operates a 6,000-hour (approximately three-year), performance- and competency-based apprenticeship program for skilled journeymen. Successful completion can lead to college credit toward an associate degree in machine technology at the local technical college.

- **Remmele Engineering, Inc.** (a St. Paul, Minnesota, firm that designs and builds special machines and automated equipment), operates apprenticeship programs in three areas—boring mill specialist (6,000 hours), journeyman machinist (8,000 hours), and precision machinist-toolmaker (10,000 hours). It also operates a certificated manufacturing technician program.

- **The National Tooling and Machining Association** (NTMA) offers a pre-employment training program and apprenticeship training programs nationally.

- **The Northeast Metro Technical College** (White Bear Lake, MN) has solicited the help of about 1,600 industry representatives in developing education programs for specific jobs in manufacturing. The manufacturers have outlined the abilities students should have when they graduate.

- **The Tri-State Manufacturing Association** (a "flexible manufacturing network" composed of 50+ small manufacturing firms in Minnesota, South Dakota, and North Dakota) offers training for its members' employees. Staff of a local technical college surveyed member needs and established a training agenda, which will cover productivity and quality improvements (including problem-solving), specific skills, and business skills.

- **The United Auto Workers,** in conjunction with Ford, General Motors, and Chrysler offers employees after-hours computer-assisted instruction in computer basics, as well as math and reading.

- Through a business partnership called **the CIM in Higher Education Alliance,** IBM provides computer-integrated-manufacturing equipment and software, support, and education to 75 two-year and four-year institutions of higher education. In return, the institutions agree to work with local industries, to integrate IBM CIM solutions in their curricula, and to train students, as well as IBM personnel, customers, and prospects, in using these solutions. In addition to educating future workers in advanced manufacturing technology, Alliance schools in 1991 provided 20,000 student days of training to today's workers.

- **Toyota USA** worked with 56 vocational schools and community colleges around the country to develop a curriculum for technicians. Nearly 1,000 students are now enrolled in this "Toyota Technical Education Network." More than 80 percent of the graduates have gone on to work for Toyota.

- **Boeing, Beech, Cessna, and Lear** cooperated to design a course in sheet metal assembly which is taught by the Wichita (KS) Area Vocational-Technical School. Most of the annual 435 graduates get jobs.

- **Honeywell, Boeing, Eldec,** and other corporations cooperated with the Applied Technology Center, a vocational school operated by two community colleges near Seattle, to develop a course in electronics assembly.

Leadership for the Future

In perhaps no other area do the interests of government, industry, and education converge more clearly than in the area of manufacturing. A healthy manufacturing industry is essential to our Nation's well-being and defense, and well-educated employees are critical to the industry's health.

A number of public and private groups have addressed these issues at a national level, specifically the need for a well-educated, appropriately trained labor

force. And many groups have focused on at least some of the issues at a local, regional, or state level. What the working group senses is lacking is a comprehensive plan giving direction to the various efforts. In the words of one working group member, "there needs to be some kind of leadership that has a strategy in place that's recognized, and that projects the image of knowing where it is going."

Another need is for better communication and closer coordination among existing groups to help avoid redundancy and to give greater momentum to individual efforts. Such a coordinating effort might be accomplished by an ad hoc council composed of representative groups from business, education, and all levels of government. An alternative is to assign a coordinating function to an existing organization that has a demonstrated knowledge of, and history of achievement in, vocational education.

In addition to providing direction, better communication, and closer coordination, leaders should focus their efforts on (1) reeducating educators and the general public about the nature and desirability of careers in manufacturing and (2) ensuring that effective vocational-technical education programs are in place in all communities, at all levels, from the lower elementary grades through postsecondary and continuing education for current workers. The following paragraphs are examples of what must be done:

Image-building

Leaders in business and employee organizations need to develop and implement strategies to promote careers in manufacturing. Educators should become informed about the opportunities and should encourage a more positive attitude about vocational-technical education in the schools.

Basic Education

Local leaders should make certain local schools have programs that demonstrate the relationship between math, reading, and writing skills and the world of work. Technical concepts and applications should be introduced in the primary grades. School programs should also encourage teamwork, and should provide opportunities for all students to practice analytical thinking and reasoning skills. Finally, programs that encourage the development of "built-in" learning skills to draw on throughout life should be instituted, particularly programs for children in the formative years.

Secondary Programs

Local leaders should ensure that their secondary schools have strong and effective vocational and technical education programs, preferably with an integrated academic and vocational-technical curriculum. State leaders should support these efforts and, in fact, should be the focus of these efforts; because state governments fund the secondary vocational education curriculum, they have the best chance to rescue it.

Postsecondary Programs

Leaders at all levels should make certain every community or region has quality vocational-technical education programs supported by local, state, and federal funding, to provide full- and part-time education and training in close collaboration with industry.

Educators and local industry should work together to make certain community colleges provide appropriate courses to meet the needs of local employees and employers.

Leaders at the state level should explore ways to support and encourage community colleges in their efforts. For example, Iowa community colleges are authorized to issue bonds so that they can offer free training programs to corporations. In North Carolina, state-supported community colleges have provided free use of facilities and other benefits to local industry.

Apprenticeships

Leaders should continue efforts to develop and provide opportunities for apprenticeships of all types for both secondary and postsecondary students. They should pursue the tasks set forth by the Office of Work-based Learning within the U.S. Department of Labor, including the

streamlining of federal regulations, coordination of policies affecting apprenticeships, and expansion of structured work-based training programs.

Curriculum

Leaders need to find ways to support development and continual updating of curriculum. As one working member put it, "Somebody's got to drive the train nationally that lets high schools, vocational schools, and two-year schools take the time to send their folks out into the plant and...create programs. We have to make the money available some way."

Curriculum Delivery

Leaders should explore ways to increase the effectiveness and speed of learning through educational technology and a multimedia approach. One aspect of this is development of standards and guidelines for identifying software and for improving the capability of software and hardware. In this regard, the U.S. Departments of Labor and Education, together with the National Institute of Standards and Technology (formerly the National Bureau of Standards), are working to set standards for appropriate development and use of educational technology.

Instructors

Leaders need to find ways to keep classroom instructors up-to-date on new equipment and processes. One approach might be job switching, whereby an instructor spends time on the shop floor while a company employee goes into the classroom.

Equipment

Industry, together with educators, needs to explore creative ways to make certain the up-to-date equipment needed for training programs is available.

Facilities and Resources

Industry and educators should look at ways they might share facilities and resources. For example, one could provide the technical knowledge, and the other the curriculum-development expertise.

Dissemination

Leaders need to find ways to disseminate information about educationally effective—and cost-effective—vocational-technical education programs to avoid expending precious local resources "reinventing the wheel." This might take the form of a national clearinghouse; on a state level, it might involve cooperative funding of a "master teacher" or a "master training officer" who works with schools or businesses to improve their practices.

Commitment

There must be a commitment from industry to invest in education and training. Creative ways of encouraging large companies, that can act as a training and resource tool, to help small companies, including their suppliers, should also be explored.

Legislation

State and federal work rules designed to protect youth from abusive work practices should be examined; such rules may in fact serve as legal barriers that prevent students from getting hands-on experience in a manufacturing environment. State and local leaders should consider legislation and policies that support local industry growth and encourage efforts to provide training for current and potential employees.

Certification

Leaders need to define quality education and develop ways of recognizing it. Certification should be supported by leaders at all levels. Certification might be done through local trade associations or by means of completing a certified training program at a manufacturing plant. Trainers and managers might be certified first, followed by a program to train and certify the first-level workforce.

Carl D. Perkins Vocational Education Act, Amended

In 1990, Congress reauthorized the previous vocational education law. The new law (in the legislation strictly termed "amendments") will become effective July 1, 1991, and will extend through fiscal year 1995.

The new law has a new title, the "Carl D. Perkins Vocational and Applied Technology Education Act Amendments of 1990." Addition of the words "and Applied Technology" reflects Congress' recognition of a need for "academic and occupational skills...to work in a technologically advanced society."

One way the Act acknowledges this need is by authorizing funding of technical preparation (tech-prep) education. Grants will be awarded to consortia of local education agencies and postsecondary institutions for four-year programs that provide a technical-preparation education program leading to a two-year associate degree or a two-year certificate. Funds may be used to, among other things, develop curricula, train teachers, and train counselors to recruit students.

The Act addresses a number of other issues discussed in this paper. The provisions are too extensive to even summarize here. A few points might be highlighted, however.

The law authorizes funding of programs that use curricula that integrate vocational and academic learning. It also provides for dissemination of information about effective integration strategies through the U.S. Department of Education National Diffusion Network.

Funds also are authorized to develop and produce instructional telecommunications materials and services for use in local vocational and technical education schools and colleges. Grants may be used for sequential courses of study that include video courseware or interactive teaching delivered by satellite, accompanied by print or computer-based materials. Funds also can be used to develop videodiscs that produce simulated hands-on training.

States are allowed to award, from their share of funds, grants to partnerships among education entities and business, industry, labor organizations, and apprenticeship programs. Grants can be used to provide apprenticeships and internships in industry, to support teacher internships or teacher training, and to strengthen coordination between vocational education programs and the labor and skill needs of business and industry. In addition, funds can be used for programs that bring representatives of business and organized labor into the classroom and for programs that address the needs of new and emerging industries, particularly industries in high-technology fields.

The law calls for establishment of one or two national centers for research in vocational education. The bulk of the funding will go for applied research and development related to such things as articulation of school and college instruction with high-quality work experience and for practices that educate students in all aspects of the industry they are preparing to enter. Dissemination and training activities may include dissemination of exemplary curriculum and instructional materials and publication of curriculum materials.

Funds also are authorized to help technical committees composed of representatives of business, labor, and education establish national standards for competencies in industries and trades. The competency standards are to cover minimum hours of study, needed tools and equipment, minimum qualifications for instructional staff, and minimum tasks to be included in courses of study.

The law also calls on the General Accounting Office to study the dual system of vocational education in Germany. Among other things, the study is to analyze the advantages and disadvantages of establishing a similar nationwide job apprenticeship program in the United States.

The law places emphasis on funding for special populations, including poor and handicapped students, students with limited proficiency in English, and single parents, displaced homemakers, and single pregnant women.

Key Issues for Business and Industry

American manufacturing faces many challenges. The greatest challenge may be in the area of human resources—recruiting and training a well-educated workforce and providing an environment in which that workforce can flourish.

The latter task may need to be the top priority. Says working group member Westra: "Much of the [international] competitiveness problem can be solved by addressing the cultural and management issues such as team-building, employee involvement, empowerment, and conflict resolution. Most of the technical training and skills-building will not be accomplished, and if accomplished will not be effective, without a motivated workforce. It would be the ultimate exercise in futility to launch a technical training program without addressing the human resources issues first."

That said, the industry needs to take a hard look at how needs for employee skills and technical training are being defined, both to meet individual business requirements and relative to foreign competitors. Skills are needed not simply to work with today's high-tech equipment. Emphasis must be placed on adaptability, flexibility, crosstraining, and a willingness and ability to adjust quickly to changing customer demand. Training must include a "learning to learn" component so that the skills are there to promote increased quality and continuous process improvement.

American industry also needs to look at the kind of work environment it is providing to encourage positive employee work ethics and attitudes. Many of the employee qualities necessary to individual and company success are intangible, less subject to classroom instruction than to development through positive work experiences. Industry management can contribute much to this development. As working group member Peter D. Hall, a vice president with the Gleason Works observes, "Through training and confidence in their skills and knowledge and an understanding of how their contribution affects the quality of the overall product and performance of the company, workers will normally be instilled with a good work ethic. A well-trained, skilled person will understand that there is no compromise on quality in manufacturing." Adds working group member Esther Whitten, Field Training Coordinator for the National Tooling and Machining Association, "Ethics and pride can be sustained only when management acts in an enlightened manner and empowers employees to act. Managers must be educated."

Addressing the human resources issues would have the added benefit of helping improve the image of manufacturing as a good career choice, something that is sorely needed if the industry is to recruit a qualified workforce. Other actions manufacturers can take are:

- ✓ Ensure that students and their adult advisers have up-to-date information about the industry and local career opportunities.
- ✓ Encourage school programs, starting in the lower elementary grades, that demonstrate the linkage between academic subjects and positive work outcomes and programs that provide practice in analytical thinking, problem solving, and teamwork.
- ✓ Seek out opportunities to serve as resource speakers in classrooms.
- ✓ Encourage understanding of the industry by welcoming student field trips and holding public open houses.
- ✓ Serve as advisers in community efforts to develop effective secondary school vocational-technical education programs.
- ✓ Hire students enrolled in school-based cooperative education programs.
- ✓ Serve as advisers to postsecondary schools on program and curriculum design.
- ✓ Explore creative ways to ensure that up-to-date equipment is available in technical education programs at all levels.
- ✓ Devise ways of keeping instructors in education programs at all levels current on equipment and processes.

- ✓ Provide apprenticeships and cooperate in other work-based training programs.
- ✓ Invest in programs of on-the-job training and continuing education for current employees and provide employee incentives for participation.
- ✓ Work to develop recruitment and education programs attuned to the special needs of the segments of the population expected to make up a larger proportion of the workforce in the future, specifically minorities and women.
- ✓ Work to define occupational competencies and standards for education/training programs.

This is a long list, and the task may seem daunting. The consequences of not acting, however, may be worse. Working group member Hall summarizes the challenges for the manufacturing industry in the following way:

> *"Although Federal and state funding and support are essential, ultimately...the success of true [vocational-technical education] and career development is the responsibility of the local community. High schools, employers, vocational schools, parents, and city administrations all have to support the programs over the long term.*
>
> *"Industry must take the leading role, as they are the only ones truly able to define their needs.*
>
> *"The CEOs of American companies are largely to blame for the present demise of apprenticeships/vocational [education] and the shortage of an internationally competitive workforce. They have the power to turn things around by committing time and money to basic training on a continuous, long-term basis.*
>
> *"We have to start at the bottom with the youth of America. They are our future, but they cannot perform without the necessary conditions and environment, which only people in senior positions in industry and education can create.*
>
> *"With a constant flow of young, creative, and productive people into the national workforce, America will be assured of its position among the world leaders...in technology, manufacturing, and export performance."*

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Resources

Agency for Instructional Technology (AIT), Box A, Bloomington, IN 47402.

Center for Occupational Research and Development (CORD), 601C Lake Air Drive, Waco, TX 76710.

National Center for Manufacturing Sciences (NCMS), 900 Victors Way, Ann Arbor, MI 48108.

National Coalition for Advanced Manufacturing, 1331 Pennsylvania Avenue, NW, Washington, DC 20004.

National Tooling and Machining Association (NTMA), 9300 Livingston Road, Ft. Washington, MD 20744.

Pennsylvania Youth Apprenticeship Program: A Work-based Learning Demonstration Project (information about project available from the office of the Secretary of the Department of Commerce, Commonwealth of Pennsylvania, Harrisburg, PA).

Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, Room C2318, 200 Constitution Avenue, NW, Washington, DC 20210.

Vocational Industrial Clubs of America (VICA), Post Office Box 3000, Leesburg, VA 22075.

SECTION II:

A Report on the Vocational-Technical Education Needs of the Aviation Maintenance Industry

Aircraft maintenance is an essential part of the U.S. aviation industry. Perhaps no other industry is more directly dependent for its success—indeed, its life—on the performance of its "behind the scenes" employees. Working between flights at some 12,000 civilian airports, at maintenance facilities operated by commercial airlines, at independent maintenance facilities, and at aircraft assembly plants, aircraft maintenance technicians ensure the airworthiness of all aircraft.

Occupational Profile

Aircraft maintenance technicians are responsible for the entire aircraft, including the airframe, the powerplant, the avionics (electronic and electrical equipment), and all the systems (for example, flight controls, pneumatics, landing gear, and hydraulics). They inspect, service, troubleshoot, repair, replace, and assemble parts of the airframe, the powerplant, and all the systems, up to and including overhaul. Some technicians are generalists who are able to work on all parts of an aircraft. Others are specialists at maintaining specific areas of the airframe, the systems, or the powerplant. Still others focus on one type of aircraft.

Many generalists in aviation maintenance are employed by air carriers as line maintenance mechanics, providing routine service and unscheduled repairs on large commercial aircraft between flights. Others are employed in the general and business aviation industry, providing service on smaller aircraft either at large airports or at the 11,000 airports around the United States that handle mostly small private planes or business aircraft. Still other generalists are highly experienced individuals who work as inspectors in all areas of aviation (commercial, business, and private), in many cases for the U.S. Federal Aviation Administration (FAA) of the Department of Transportation.

Many aviation maintenance specialists perform scheduled work and conduct FAA-required inspections at facilities operated by commercial air carriers. Others work at certified repair stations and at facilities where components are manufactured or aircraft are assembled.

In 1988, 106,000 U.S. civilians worked as aircraft mechanics, according to the U.S. Bureau of Labor Statistics (BLS). Approximately 40 percent worked for the scheduled airlines, more than 25 percent worked for the federal government, and more than 10 percent worked for aircraft assembly firms. Most of the remaining were employed by general aviation independent repair stations or by nonscheduled airlines, crop-dusting and air-taxi firms, and businesses that use their own planes for employee or cargo transportation. Most aircraft maintenance technicians work near large cities. Many live in less populous areas throughout the country, however.

An Expanding Industry

Aircraft maintenance technicians are vital to the economy of the United States. Conversely, the future of the occupation depends in large part on economic conditions in the country. In a strong economy, the public as well as businesses will continue to use air transportation regularly, the number of flights will remain steady or increase, and the workforce will need to grow; an economic downturn may bring slower growth and even workforce reductions.

At the end of 1990, the U.S. commercial fleet was growing rapidly, with new orders the largest in aviation history (a U.S. fleet of approximately 4,000 and another 1,200 on order through the end of the century). The sheer size of this expansion suggests that the industry will require far more maintenance workers over the next decade. Moreover, these new, sophisticated aircraft are very complex and will require highly skilled maintenance technicians.

The new aircraft being integrated into the U.S. fleet over the next six to ten years will not necessarily replace existing aircraft. Fewer than half will be replacements, which means that in the near future more than half of the nation's air fleet will be 20-25 years old. Moreover, many that are replaced will not truly be retired, but will be used by second- or third-level operators. These aging aircraft will require special attention. New standards for corrosion prevention and control on the aging commercial fleet currently are being formulated; when implemented, these new standards will create a need for more specially trained workers. Also being formulated is a program for reviewing and replacing major airframe repairs made prior to implementation of damage-tolerance design repairs in October 1978. In a 1990 interim report, the U.S. General Accounting Office (GAO) estimated that regulatory changes to ensure the safety of aging aircraft would affect about 1,400 of the 4,100 planes in the U.S. fleet over the next four years.

> ***I don't believe there is any other industry that requires the technology of a person that the airlines do. We require our mechanics to be able to work on eight different aircraft, and to work on those aircraft from computers through engines.***
>
> **Rod Peters**
> *Director of Technical Training*
> *Northwest Airlines*

Future Labor Needs

Given the anticipated increase in the size of the air transport fleet between now and the end of the century, the large number of new aircraft requiring highly trained maintenance personnel, the large number of aging aircraft requiring special maintenance, and an expected increase in general aviation, it is clear that the industry will require many additional aircraft maintenance technicians over the next decade.

Projections of the exact size of the need vary. The Bureau of Labor Statistics (BLS), which placed the number of aircraft mechanics in 1988 at 106,000, believes that with moderate economic growth, 124,000 will be needed by the end of the century, a 17% increase. (The equivalent BLS figures for aircraft mechanics and engine specialists are 124,000 in 1988 and 144,000 in 2000, a 16% increase.)

The BLS projections are for the total number of personnel needed. Other

projections take into account such factors as retirements, which are expected to be substantial over the decade, and become estimates of new personnel needed. These projections indicate that the need will be great. Working group member Gene Little, Chairman of the Department of Aviation at San Jose (Calif.) State University, estimates that 60,000 new mechanics may be needed by 1995. Future Aviation Professionals of America predicts that by 1997, 46,000 additional aviation technicians may be needed by the scheduled airlines, and another 20,000 or so by general aviation and related industries, including aerospace. *Aviation Week & Space Technology* magazine (April 23, 1990) projects a need for 70,000 new mechanics through 1998. Working group member Richard E. Devereux, Manager of Special Programs in Maintenance Training for the Boeing Commercial Airplane Group, estimates that 35 percent of the work force may need to be renewed by 2000. Working group member Mary Alice Rice, President of Rice Aviation Maintenance Schools, estimates that in Texas alone, 4,000 new jobs in maintenance (plus 3,000 related aircraft positions) may need to be filled within the next three to five years. A spokesman for one major carrier says that it needs about 25 maintenance technicians for each new aircraft; attrition at that carrier is about 600 a year.

Working group member Jack J. Howlett II, Publisher of *Aviation Equipment Maintenance* magazine, points out that the future need is very difficult to quantify because it depends on such variables as fuel prices, noise regulations, and factors that affect the usefulness of older aircraft. To his list of variables might be added the condition of the U.S. economy and voluntary or mandated maintenance standards.

Despite the difficulty in quantifying future requirements, it is clear that a large number of additional aircraft maintenance technicians will be needed over the next decade. In its 1990 interim report, the GAO identified a shortage of skilled aircraft mechanics in some markets as one of the immediate obstacles to expanding aircraft repair capacity. Further, the increasing need will be coming on top of an already tight situation. In a 1989 survey of the nation's 21 largest carriers, for example, the Air Transport Association found that about 4,000 of their 69,000 mechanics positions were vacant. The demand, particularly for experienced personnel, may be especially great in other segments of the industry, for example, general aviation and smaller companies, where wages are lower and benefits fewer. One official says the days are gone when his company could expect to hire people with experience. Adding to the problem is the fact that aircraft maintenance operates in an international context. There is a shortage worldwide, and competition for workers can be tough.

Important Work for Those Who Qualify

Given current shortages and a need expected to grow over the next decade (assuming a healthy economy), aviation maintenance offers a promising career choice. Jobs are plentiful and are available throughout the country (and, indeed, throughout the world)—in large cities, small towns, even rural areas. The pay can be quite good, with starting wages as high as $12 an hour and higher (as much as $15 an hour or more) in some settings and some regions of the country. And few jobs are as important, owing to the critical safety issues that are involved.

The career is not for everyone, however. It requires specialized knowledge, well-honed skills, and tremendous dedication to doing a job right day after day. Moreover, the work can be physically demanding, as inspections and repairs may have to be done in inclement weather, in confining crawl spaces, or from elevated work platforms. In addition, work schedules may include night shifts, rotating days off, and overtime, weekend, and holiday work.

Academic Preparation and Skills

Secondary Education

Young people preparing for careers in aviation maintenance should have a high school diploma, preferably graduating in the

top half of their class (graduation in the middle third will also qualify many students). A solid basic education is a must: good skills in arithmetic and basic algebra (including measuring and graphing skills), reading at the 10th grade level or better, and good written, oral, and listening skills. The importance of reading and communication skills cannot be overemphasized, as technicians must read and interpret highly technical manuals and provide logical, coherent oral and written reports of completed work.

Beyond this basic academic foundation, additional high school courses in math (particularly geometry) and science (physics and chemistry) are desirable (although it is recognized in the field that students who find fundamental math and science courses difficult may be very competent mechanics). Computer literacy is an asset. Classes in electronics, mechanical drawing, shop (machine, electrical, sheet metal, and welding), and auto mechanics also are helpful. Classes in aviation are a big plus. Also important are courses that encourage development of the analytical thinking, reasoning, and deduction skills needed to troubleshoot complex equipment.

Personal Skills

In addition to a strong academic foundation, young people contemplating a career in aviation maintenance need to be able to work with precision, to exacting standards. They must be skillful in working with their hands, have good eye-hand coordination, and be able to interpret blueprints and diagrams. They also must be in good physical condition because the work requires strength and agility.

Postsecondary Education

Although not strictly required for work in aviation maintenance, the best preparation is completion of the basic aviation maintenance program at a postsecondary school that has been certified by the Federal Aviation Administration (FAA). These 12-to-14-month programs can provide entry into general aviation, corporate aviation, manufacturing, and air carrier positions. The programs are described in the following section, "FAA-Approved Postsecondary Programs." FAA-approved two-year courses also are available in some high schools and colleges.

FAA-Approved Postsecondary Programs

The Federal Aviation Administration has established minimum competency requirements for technicians working on aircraft airframes and powerplants. These competencies are described in Federal Aviation Regulation Part 147 (FAR 147). Postsecondary programs offering courses that cover these competencies can apply for certification, or approval, by the FAA. Schools that receive approval must offer a specific curriculum and must attest to the competency of students at the conclusion of the program. Although completion of a FAR 147 program (often called an A&P program, for airframe and powerplant) may not be necessary for employment, it is an excellent way to prepare for a career in aviation maintenance.

In 1990-91, there were approximately 170 FAA-approved FAR 147 schools operating throughout the country (in 44 states, the District of Columbia, and Puerto Rico). Some are part of the vocational-technical education programs of junior colleges and public school districts; others are profit or nonprofit private schools. Some offer primarily the basic FAA-approved FAR 147 education; others offer the FAA-approved education as part of a broad degree-granting program in several areas related to aviation maintenance.

The basic programs offered by FAA-approved schools vary in length; most provide about 2,000 hours of classroom and hands-on work (the FAA-required minimum is 1,900 hours). The programs generally run from 12 to 24 months, depending on whether the program is completed on a full-time or part-time basis. Costs range from a few hundred dollars to $15,000 for the entire program. (Personal hand tools, required as part of employment, are additional. Their cost may range from $1,500 to $2,000.) Financial aid, including the types of federal aid available for attending four-year institutions, generally is available.

A high school diploma or a GED or its equivalent is required for admission to most FAR 147 schools. Special background knowledge related to aviation is not required. Some schools offer assistance in basic education skills, and some provide (and may require) a technical preparatory program for students lacking appropriate high school courses in math, science, and English comprehension/communications.

The basic curriculum for airframe and powerplant technicians covers such topics as structures and coverings; welding and sheet metal; powerplant installation, operation, and maintenance; and systems (electrical, fuel, pneumatic, and hydraulics). Students receive both classroom and hands-on experience in fabrication, repair, assembly, and disassembly.

Completion of the basic FAR 147 program alone does not result in FAA certification or a degree. However, it does prepare students for FAA examinations (see following section, Competencies and FAA Certification). At many schools, arrangements can be made to tie attendance to an associate degree.

Completion of the basic airframe and powerplant technician program also can be a springboard for specialized education in such areas as avionics (electronics and electrical, especially as applied to navigation, communication, and instrument systems), helicopter inspection and maintenance, and applied engineering.

Competencies and FAA Certification

Competencies

As noted earlier, the Federal Aviation Administration has established minimum competencies for aircraft maintenance technicians. These competencies cover all types and sizes of fixed-wing aircraft, wood and composite structures, and reciprocating and jet engines. Obviously, a 1,900-hour program cannot cover all that is needed to work on a state-of-the-art jet transport system. Moreover, the current competency levels are based on standards established in the 1970s. For all but a few work settings, completion of an FAA-approved program should be viewed as "basic training" that prepares a graduate for more specialized education (usually at the new place of employment). Realistically, competencies are established and maintained by the major aviation industry employers. These additional competencies may be in such areas as large transport aircraft; avionics, including logic circuits; nondestructive testing; structures repair; or composites.

FAA Certification

The FAA provides certification for aircraft maintenance mechanics, with separate ratings in airframe (A) and powerplant (P) maintenance, or a rating in both areas (A&P). An individual does not necessarily need certification to work in aviation maintenance, but many employers (especially large air carriers) use it as one of several hiring requirements. An individual working without a certificate must, according to FAA regulations, work under the supervision of a certificated individual and is not allowed to release aircraft to service. The holder of an A&P certificate is allowed to perform, teach, or supervise many aspects of aircraft maintenance.

The eligibility requirements, procedures, privileges, and limitations related to A&P certification are detailed in Federal Aviation Regulation Part 65 (FAR 65). Generally, an individual must: (a) be 18 years old, (b) be able to understand the English language, (c) either have graduated from an approved FAR 147 school or have 18 to 30 months of certifiable work experience, and (d) pass comprehensive written, oral, and practical examinations.

An A&P certificate is valid for a lifetime and need not be renewed, unless it is surrendered, suspended, or revoked. Although it is not required for employment, a certificate may be a prerequisite for additional education in related areas. The certificate is a prerequisite for obtaining additional recognition by the FAA, such as an Inspection Authorization (IA), which allows an individual to conduct annual inspections and to conduct and supervise progressive inspections. It also is a prerequisite for working for the FAA as a maintenance inspector.

Work Ethics for Public Service

Aircraft maintenance technicians deal daily with people's lives. There are no shortcuts. Further, the importance of technicians will grow as new aircraft—dependent more and more on new technology, automation, and computers and less on human interface—are integrated into the commercial fleet.

Safety awareness, honesty, a sense of responsibility, dependability, commitment to task, and dedication to quality are critical to work in the field. Leadership, professionalism, a spirit of teamwork, and a commitment to lifelong study to keep up with technological advances are essential to success as an aircraft maintenance technician.

These work ethics are not only necessary to ensure public safety but are in the best interests of those working in the field. The aviation industry is an internationally competitive business, and productivity is a key to keeping the United States a leader in aviation production and service. Continued job security of the workforce is tied to the success of the industry.

On-the-Job Training

On-the-job training is an important aspect of a career in aviation maintenance. This is especially true for work on large, modern transport aircraft. Working group members from the air transport segment of the industry agree that even a newly issued A&P certificate should be viewed as a "permit to learn," as it reflects a foundation of knowledge but does not ensure the specialized knowledge necessary for most jobs. Working group member Ray Goldsby, Director of Maintenance Training for United Airlines, reports that his company expects to give entry-level employees three to ten weeks of OJT beyond their initial formal training.

The need for on-the-job training is not restricted to entry-level employees. Working group member Devereux reports that students who attend the Boeing maintenance training school in Seattle—entry-level, mid-level, and supervisory employees—receive a mixture of factory, academic, simulator, and computer-based training. United Airlines devotes at least 2% of paid hours annually to recurrent training for mechanics and their supervisors. Another major carrier will spend $11 million on training in 1991.

> ***The most important training for the airlines is on-the-job training. It is still the backbone of all the training our mechanics do.***
>
> **Rod Peters**
> *Director of Technical Training*
> *Northwest Airlines*

Continuing Education

Continuing education also is essential for aircraft maintenance workers. New aircraft with computerized and advanced hardware are being integrated continually into the national air fleet, and new skills will be needed to service and update older equipment. Working group members particularly note the need for continuing education in aging-air-fleet inspection and surveillance, corrosion control, composites, avionics, digital logic, and specific aircraft and components.

As mentioned earlier, the FAA does not require recurrent training or recertification of technicians in either airframe or powerplant maintenance. Generally, the responsibility for continuing education rests with the employer or the certificate holder. Some employers provide after-hours courses. Local community colleges are another common source of continuing education. Individuals also can stay current by reading trade journals and manual revisions.

The FAA has developed a voluntary "Back-to-Basics II" recurrent training program for maintenance technicians that is designed to increase safety and reduce accidents. The program is expected to run for five years, with a different emphasis every six months. FAA-led seminars and related activities will focus on federal regulations and training in technical subjects.

Meeting Future Labor Needs

Clearly, the aviation industry will need to hire a large number of new and experienced maintenance personnel over the next decade. Working group member William C. Bottoms, Executive Director of Colorado Aero Tech, summarizes the challenge as follows:

> *"Between now and the turn of the century, the worldwide air transport fleet will nearly double and retirement of aircraft will be minimal. At the same time fleets are expanding with the latest equipment, we are looking at restoring the operating credibility of the previous generation of equipment. Simultaneously, literally thousands of experienced A&P technicians will retire. The bottom line is that there will be a need for tens of thousands of well-trained entry-level technicians between now and the year 2000."*

Meeting the need will depend in large part on the size, composition, and qualifications of the labor pool; success in recruiting potential employees; and retention of workers already in the industry.

Source of New Workers

The Bureau of Labor Statistics projects that between 1988 and 2000, the labor force will grow about 1.2% annually (a much slower rate than during the preceding 12 years). This represents a net increase of 19 million workers.

The fastest growing segments of the labor pool will be Hispanics, Asians and others (including Asians, American Indians, Alaskan Natives, and Pacific Islanders), Blacks, and women. The annual growth rate for Hispanics is projected to be 4%; by 2000, this group is expected to make up 10% of the labor force, up 3% from 1988. Comparable figures for other groups are: Asians and others, 3.6% annual growth rate, 4% of labor force in 2000, up 1% from 1988; Blacks, 1.9% annual growth rate, 12% of labor force, up 1%; women, 1.7% annual growth rate, 47% of labor force, up 2%. The teenage labor force is projected to decline until 1992 and then rise over the rest of the decade.

> ***The retraining process is a major challenge to us in the next ten years.***
>
> **Robert Jardee**
> *Director*
> *Metro Tech Aviation Career Center*
> *Oklahoma City*

These projections for labor force size and makeup, when taken together with data on education and literacy, have important implications for the aviation industry. Over the period 1988-2000, the groups in the workforce growing most rapidly show a lack of educational achievement. Yet, the new workers required for the aviation maintenance industry will need to have a strong academic background.

Recruitment of New Workers

The recruitment of new technicians to aviation maintenance is a twofold challenge: attracting enough to fill the great need, and attracting high-quality candidates capable of working on today's sophisticated equipment. Success in these endeavors appears to depend on (a) getting out the word about the advantages of working in the field, and (b) improving the image of aviation maintenance as a career.

Young people and their advisers—school counselors and parents—as well as the public must be made aware of the occupation and that it offers many opportunities and benefits. Lack of visibility appears to be a problem. One working group member tells of asking 100 high school students to list five jobs associated with the aviation industry. Not once in 500 answers was technician or mechanic listed. One major airline recently gave the occupation national visibility by using a mechanic in its national television advertising. Visibility campaigns need not be so large or costly, however. In fact, many things can be done at the school and community levels.

Efforts to interest young people in aviation maintenance careers should begin in elementary schools. Programs can take

advantage of children's natural interest in model and remote-controlled airplanes, airports, and building things (that is, the "manufacturing process"). Such early efforts also give students a chance to plan for the necessary education foundation.

High school students need concrete information on the occupation, such as what the work entails, employment opportunities, academic preparation, salaries and opportunities for advancement, and where they can get more information. Recruitment should focus on students in the top half to two-thirds of the class academically. (Properly developed programs also may increase the focus of the middle third and stimulate the lower third of the student population.)

Teachers and counselors who provide information on careers and guide course selection are critical elements in a recruitment effort. They also need information on opportunities in aviation maintenance, the kinds of students who are good candidates for the occupation, the academic preparation needed, and earnings potential.

Much of the burden for recruiting young people to aviation maintenance rests on the industry itself. Industry representatives need first to work with school systems to raise teacher and counselor awareness, and then to develop information programs. They might provide special summer internships for teachers or host tours of their facilities by local or state teacher groups. They can make presentations at school career days, develop videotapes and print materials for use in schools, encourage field trips to their facilities, support school clubs that focus on aviation or vocational education, and work with students enrolled in arts, crafts, and vocational education classes. Representatives of industry also can work with school systems to develop vocational education programs, and then help by donating equipment, training aids, and course materials and by working to gain community support. They can support cooperative education programs and provide scholarships for postsecondary technical education.

Recruitment efforts also should be directed toward colleges and universities. According to a National Council on Vocational Education report titled *America's Hidden Treasure*, 80% of high school graduates who go immediately to college do not stay in for four years. Students who do not want to continue their college studies may be prime candidates for technical education.

Awareness campaigns directed toward the community also are important. Among the most effective might be open houses that give the public an opportunity to get close to the aircraft and to talk with those already working in the field. Newspaper articles focusing on aviation maintenance as a career or highlighting local opportunities also might be effective. Participation in job fairs is important, as are newspaper and television ads directed toward young adults who may be searching for a career. Another source of recruits might be hobby groups in the community (for example, hot rod or computer clubs). Finally, currently employed maintenance workers might be enlisted in a recruitment campaign and may be able to make referrals.

The ultimate success of recruitment efforts may depend on improving the image of aviation maintenance as a career choice. This may be a matter of both cosmetics and substance. Some believe the traditional job title of mechanic, which is still used by the FAA, should be changed. As working group member Devereux points out, "high-tech, automated equipment at $120 million a copy [the 1990 cost of a 747] doesn't need maintenance personnel who have the traditional image of coveralled grease monkeys who talk tough, carry lunch buckets, and put up with labor union strikes." Indeed, today's maintenance technician must be highly skilled, and those completing formal preparation for the A&P examination have undergone 1,900 hours of coursework— considerably more than the approximately 1,680 needed for a college degree.

The image problem must be viewed in the larger context of vocational-technical education in general. In recent decades, the public has come to view anything less than a college education as inferior. This attitude is reflected by the schools, to some extent understandably, as schools and their staffs are judged by scores on standardized tests and

the percentage of graduates going on to college...even though, according to some estimates, 70% of the jobs in America in the year 2000 will not require a college education. In some schools, vocational-technical education is a neglected program, and representatives who might come to speak to students about continuing their education in a trade school (in this case, an A&P school) are not welcome.

In addition to highlighting the importance of aviation maintenance, the highly technical skills it requires, and the competitive salaries (the average annual salary of graduates of A&P schools going to work for an airline is $30,000, compared with maybe $22,000 for an average college graduate), the industry can do other things that could raise the status of the field. One suggestion is to work for reform of the certification process, which to some seems to equate maintenance technicians with unskilled labor. Another possibility is to provide more recognition for students entering the field through awards and scholarships. A third suggestion is a system of awards giving national recognition to current employees for outstanding work. Finally, the industry might support a Senate resolution to establish a national week honoring aviation education and educators.

Retention of Current Employees

There are few hard figures on the departure of experienced aircraft maintenance technicians from the field. One organization suggests that as many as 25% of A&P school graduates leave the field within one year of entering it, but another survey found that approximately 85% of graduates were working in the field five years later. Departure from the field is not seen as a serious current problem by working group members. Those who appear to have left the field most likely are working in a related field that values an A&P education, are working under a different job title, are private aircraft owners who obtained the education in order to work on their own planes, or are foreign nationals who have returned to their home country.

Movement within the field appears to be from small operations to the major air carriers, primarily for higher wages. Working group members believe retention is directly related to job security and benefits. They suggest good supervisory practices, timely promotions, rewards and recognition programs, and, when possible, work rotation to vary assignments as ways to increase employee retention.

School Capacity as a Limitation

An important element in meeting the demand for aircraft maintenance technicians is postsecondary education, specifically A&P school education. Currently, there are more than 170 A&P schools nationwide. An estimated 80% of graduates come from ten schools, however, and in a recent two-year period, an estimated 20% of graduates taking the A&P exams came from three schools.

It has been estimated that even if all the currently certified A&P schools in the country produced graduates at their maximum capacity, the demand for entry-level technicians over the next five to ten years would not be met. Some private schools are able to begin programs when the need arises, starting with new enrollees as often as every four or five weeks. When A&P instruction is provided by public community colleges, the schedule may not be as flexible. Working group member Rice reports that in one area in Texas, school districts have put a cap on the number of students who may go through the program, and hopeful enrollees have been known to camp out overnight in sleeping bags to get a good position in the registration line.

The number of FAA-approved schools has been growing steadily, with ten or so applications being processed in 1990. The cost of initiating such programs is high, however, and may be a factor limiting growth.

The main factors limiting the capacity of currently operating schools (in addition to possible local school district constraints or traditions) are lack of equipment for hands-on training and lack of qualified instructors. The shortage of instructors might be eased by wider use of computer-aided and

computer-managed instruction for the FAR 147 general curriculum and for some of the airframe/powerplant curriculum. Such instruction might have the additional benefits of making training more efficient, reducing costs, and standardizing learning materials nationwide. Computerization would not be a substitute for hands-on instruction, however, and until these problems are solved, the shortfall of A&P technicians is likely to continue.

Relationship Between Civilian Needs and the Military

Aircraft maintenance for the U.S. military is not directly tied to civilian needs. However, there is an indirect relationship in supply and demand.

At one time, aircraft mechanics leaving the military were a primary source for civilian employment. Although their skills were specialized, they did offer experience in the field. According to working group member Goldsby, in the past, 60% or more of hires at United Airlines came directly from the military. That situation has changed considerably. Now, the military is a less significant source, and United now hires fewer than 40% directly from the military.

Working group member Bottoms notes that the military is recognizing the importance of retaining well-trained technicians and is encouraging young people to stay in the service, thus reducing the resource base. Further, today's complex technologies demand greater expertise than most military mechanics have, meaning that more and more will need to go through the postsecondary education system to work in civilian aviation. Those leaving the military do remain a good source of recruits for postsecondary education leading to civilian work, however.

The military also can have some effect on demand for civilian maintenance technicians. There are currently thousands of civilian workers (not necessarily A&P certified) employed by the military performing all levels of aircraft maintenance. For example, the U.S. Air Force has been using civilian contractors to service its electronics. The extent of the military's effect on the future demand for civilian workers is not clear.

Cooperative Efforts to Meet Demands

Providing adequately trained aircraft maintenance technicians in the quantities necessary to meet anticipated future needs will take a cooperative effort among industry, education institutions, labor organizations, and government. That effort must begin in elementary schools and extend through the reeducation of current employees.

As a start, the industry should define its needs, in terms of numbers and skills, and make these needs known to the education community and to government at all levels. Together, these groups then should develop a broad plan to ensure that the needs are met. The plan, along with supporting materials, should be disseminated through a national network, possibly the Professional Aviation Maintenance Association (PAMA), the Aviation Technician Education Council (ATEC), and/or the Air Transport Association (ATA).

The plan should address recruitment, education, retention, retraining, and certification. The following actions should be considered.

- **To increase awareness and recruitment, industry should:**
  - Invite educators, students, and the public into their workplaces.
  - Seek opportunities to make presentations to school and community groups.
  - Designate certain employees to work with elementary and secondary schools.
  - Sponsor aviation-oriented school clubs and other technically oriented school groups.
  - Provide support for school science fairs.
  - Hire students part time.
  - Give special attention to groups that are expected to make up a larger proportion of the labor pool in the next decade (minorities and women).

- **To strengthen elementary and secondary education programs, industry should:**
  - Adopt a school or a school district for special attention.
  - Support applied courses (for example, applied mathematics) by developing examples and projects that demonstrate how academic learning is useful in the world of work.
  - Help vocational education instructors stay current by providing internships or other educational programs.
  - Help vocational-technical education programs acquire expensive equipment and learning aids through donations or loans.

- **Educators and industry should work together to:**
  - Improve the image of vocational-technical education in general and the career of aviation maintenance in particular.
  - Develop and disseminate realistic student-oriented information on careers in aviation maintenance, including job requirements, academic preparation, salary expectations, and advancement opportunities.
  - Identify the kinds of high school students who are promising candidates for careers in aviation maintenance, with special attention to students in the top half to two-thirds of their class academically.
  - Develop vocational education programs in aviation in high schools, as well as courses useful to careers in the field.
  - Develop cooperative education and internship programs to give secondary students hands-on experience in the field.

- **Educators need to:**
  - Recognize that not all jobs require a college degree, and not all quality students will thrive in a traditional four-year institution of higher education.
  - Learn about the opportunities in aviation maintenance.
  - Offer courses in applied math and science and technical English to give students experience in transferring theory into practice.
  - Make certain elementary education and secondary courses include opportunities for students to develop and practice analytical thinking, reasoning, and deduction skills.
  - Support activities that keep vocational-technical education instructors current with industry developments, including leave time for continuing education, attendance at trade shows, and acquisition of training aids.

- **To increase postsecondary educational opportunities, industry should:**
  - Work with state officials in vocational-technical education to identify statewide needs.
  - Work with the education community and local and state governments to develop regional air transportation education centers.
  - Provide scholarships and other financial assistance to students.

- **To increase effectiveness, postsecondary schools should:**
  - Consider ways to utilize facilities more efficiently (for example, by operating programs year-round or operating in shifts, if not already doing so).
  - Work with industry to make certain that the curriculum is up-to-date and meets workplace needs.
  - Explore creative ways to keep instructors up-to-date on technological developments.

- **Industry should assist postsecondary programs by:**
  - Serving in an advisory capacity.
  - Helping instructors stay current, possibly by offering in-house recurrent training, or by providing industry employees to

cover the classroom so school instructors can participate in update training.

- Working with schools on arrangements whereby retiring employees become instructors.
- Providing equipment for use in schools.

■ **To improve the status of the profession, increase employee retention, and ensure a workforce skilled in current and new technologies, industry should:**

- Offer retraining and upgrading opportunities to employees and facilitate their participation.
- Become more involved in and support advanced training in such areas as composite repair technologies, "fly-by-wire" troubleshooting, digital logic, improved nondestructive inspection procedures, and avionics (possibly by working more closely with equipment manufacturers).
- Adjust pay scales to reflect additional training.
- Support FAA efforts to recognize recurrent training and outstanding work, and nominate employees for such awards.

■ **Industry, together with national industry and employee groups, should:**

- Help students by providing scholarships, grants, forgivable loans, and other financial assistance for postsecondary and continuing education.
- Explore creative ways to aid postsecondary programs (for example, by setting up a clearinghouse for information on educational materials, equipment available for donation or loan, and the availability of instructors).
- Develop and disseminate strategies for recruitment of high-quality candidates for aviation maintenance careers.
- Develop model programs for high school vocational education programs in aviation maintenance, and provide support to communities that implement programs.

■ **Labor organizations should get involved by:**

- Supporting cooperative education programs, internships, and apprenticeships that enable young people to gain hands-on experience in a work environment and educators to get a first-hand look at the requirements of careers in aviation maintenance.
- Encouraging members to participate in recruitment activities in schools and the community, in career fairs, and in air shows.
- Supporting job classification structures that acknowledge the difference between today's high-tech personnel and unskilled workers.
- Developing flexible work rules (for example, part-time employment to cover needs during peak hours and cross-utilization of workers, allowing workers in one job classification to perform other jobs when necessary).

■ **Governments should:**

- Consider adopting tax structures that encourage individuals to continue their education and businesses to provide retraining and recurrent training for their employees.

■ **The FAA should:**

- Expedite implementation of recent revisions of FAR Part 147.
- Continue to update requirements for A&P certification.
- Provide for updating of the curriculum offered by FAR 147 schools.
- Institute certificate ratings for additional specialties (for example, transport maintenance technician, avionics technician, and nondestructive inspection).

Programs to Recruit and Prepare Workers

Schools and community colleges, government, and industry groups, working alone or in partnership, have initiated a variety of programs to recruit and prepare aircraft maintenance technicians. Some of those programs are described here.

- **Southern Illinois University** has produced a videotape on women in aviation careers, including aircraft maintenance.

- **United Airlines** has produced a videotape promoting careers in aviation maintenance and has developed recruitment materials. The company also provides training materials and equipment to schools, and technical training, internships, and seminars on new technology for A&P school and college instructors.

- **Northwest Airlines** is developing recruiting material aimed at minorities and offers scholarships to technical colleges targeted to minorities. The company also provides training materials to schools and internships for instructors.

- **The city of San Jose, California,** is developing a magnet school program in aviation. Two elementary schools, two junior high schools, and two high schools will be involved. Phoenix, Arizona; Long Beach, California; and New York City have aviation high schools.

- **The FAA** operates eleven Aviation Education Resource Centers around the country to provide education programs, publications, software, and videotapes for use by students and teachers. Among the resources available are information booklets on careers in aviation (including women in aviation), instructional materials for students at all levels to enrich general studies programs in concepts relating to aviation, and aviation science activities for elementary students. Also available is the Aviation Science Information Program, which uses Apple IIe software to describe the principles of flight, navigation and flight planning, and aviation and the environment; the self-paced computer program is designed for students in grades 6-8, but it also has applications for higher grade levels.

- **The Academy of Model Aeronautics** (AMA), a nonprofit organization, provides information about classroom educational projects centered around aviation and model-airplane building. One such program, a cooperative effort among the AMA, the FAA, the Education Committee of the Hobby Industry of America, and other groups, is the Delta Dart project for students in grades 3-12. The AMA also offers college scholarships to young people who have been involved in model aviation.

- **The Experimental Aircraft Association** (EAA) Aviation Foundation sponsors a program called Project Schoolflight that trains and guides educators and other youth leaders in helping students build airplanes. The program, which has operated in high schools, trade schools, and technical schools, combines academics and the practical application of skills. Students are involved in such things as blueprint reading, metalworking, welding, woodworking, fabrics, engines, and hydraulics. The Foundation also sponsors a 17-day summer "Air Academy" for young people age 15-17 who are interested in aviation. Participants receive classroom instruction in aviation history and fundamentals as well as hands-on workshop experience in welding, composites, woodworking, fabric, sheet metal, engines, and aircraft restoration and building.

- **The Pasco County (Fla.) school system** offers a summer school course in Model Aeronautics for economically disadvantaged and handicapped junior and senior high school students. Students learn English, math, general science, electronics, flight-related physics, and small-engine maintenance as they build and fly radio-controlled model airplanes.

- **Colorado Aero Tech,** a private A&P school, is working with a local school district to offer general studies classes in aviation for high school seniors. The program will have FAA approval, and the

coursework will be transferable to any A&P school in the country the student subsequently chooses to attend.

- **WestAir,** a regional airline, conducts a six-week summer intern program to give California community college students supervised hands-on and "over the shoulder" training. Housing is provided, and students are paid for their time.

- **The Texas Employment Commission** screens, tests, and recommends potential employees to the Mountain View College continuing education program for 160 hours of hands-on training in sheet-metal assembly for aircraft.

- **In a partnership effort among government, industry, unions, and education, the Minnesota legislature** is providing about $500,000 and **Northwest Airlines** about $1.2 million to help postsecondary schools increase their output from about 220 to 600 mechanics per year. Northwest also furnishes four full-time instructors to teach large jet transport technology at Minnesota technical colleges, provides internships and training materials to the colleges, and has a representative on the advisory boards of four technical colleges.

- **SimuFlite Training International,** which provides training in corporate business jet maintenance, offers student scholarships distributed through the Professional Aviation Maintenance Association.

- **Metro Tech Aviation Career Center** (Industry Training and Development Division) of Oklahoma City provides training updates on original equipment for local industry. Because the training is local, industry costs are lower, more employees can attend, and participants miss less work.

- **Pratt & Whitney,** a manufacturer of jet engines, has a partnership training agreement with the Connecticut Vocational Adult Education System to deliver a developmental training program for aviation mechanics.

- **Martin Marietta,** a manufacturer of aircraft components, endows teaching fellowships at universities and provides cooperative education and internship programs.

- **The FAA,** together with industry, sponsors a "Mechanic of the Year" award. It is working on a project to allow A&P schools to send their students to the Skill Olympics sponsored by the Vocational Industrial Clubs of America.

Summary of Key Issues

Over the next decade, the aviation industry may need to hire tens of thousands of entry-level maintenance technicians. These new employees will need to be well-grounded in math, science, and communications; willing to engage in lifelong learning; dedicated to performing at the highest level of competence; and committed to the highest work ethics.

Where will these individuals come from? The fastest growing segments of the labor force generally show lower academic achievement. This, combined with an overall decline in educational achievement among young people, means that competition for well-prepared high school graduates will be keen. Recruitment efforts must overcome an additional obstacle—public sentiment that anything less than a four-year college education leading to a white-collar job is second rate.

The growing need for entry-level aviation technicians who have an increased level of knowledge and skills will place a burden on A&P schools—the traditional route to a career in aviation maintenance. Of particular concern is a shortage of both qualified instructors and sufficient resources to provide hands-on experience on the costly new technology in today's transport aircraft. Also of continuing concern is the FAA-mandated A&P curriculum, which is outdated and provides only a broad foundation for additional training in most work settings.

Today's complex aircraft and new technologies, together with requirements for restoring aging aircraft, necessitate continued retraining of the current workforce. This need

also places demands on education resources, as well as on individual employees and employers.

The current A&P certification requirements do not recognize the increased complexities and responsibilities of the maintenance position. Recent efforts at revision, while welcome, are insufficient either to ensure minimum competencies in specialized areas or to grant additional status for technologically demanding work. Efforts currently under way within the FAA to accomplish needed revisions to FAR Part 65 are in the beginning stages and will take about three years to complete. Every effort must be made to expedite this undertaking.

The United States has been, for many years, a world leader in the production and service of aircraft. This role requires a large, well-trained maintenance workforce.

If the workforce demand is to be met, the key issues—recruitment, education, retraining, and certification—will have to be addressed in an aggressive, cooperative effort among industry and business; the education community; federal, state, and local governments; and national organizations representing these groups.

For Further Information

Organizations

Academy of Model Aeronautics
1810 Samuel Morse Drive
Reston, VA 22090
(Nonprofit organization representing nearly 200,000 members interested in building and flying model aircraft)

Aerospace Industries Association (AIA)
1250 I Street, NW, Suite 1100
Washington, DC 20005
(Trade association representing approximately 50 manufacturers of commercial, business, and military aircraft, helicopters, aircraft engines, missiles, spacecraft, and related components and equipment)

Air Transport Association (ATA)
1709 New York Avenue, NW
Washington, DC 20006
(Trade association representing 24 U.S. scheduled airlines involved in domestic and international passenger and cargo operations)

Aviation Maintenance Foundation International
Box 2826
Redmond, WA 98073
(Organization whose members include aviation maintenance personnel, schools, companies, and related organizations)

Aviation Technician Education Council (ATEC)
2090 Wexford Court
Harrisburg, PA 17112
(Association of schools offering A&P education)

Experimental Aircraft Association/Project Schoolflight
EAA Aviation Foundation
Wittman Airfield
Oshkosh, WI 54903-3065

Federal Aviation Administration (FAA)
U.S. Department of Transportation
800 Independence Avenue, SW
Washington, DC 20591
(For information on A&P certification, contact Office of Flight Standards, Aircraft Maintenance Division, AFS-300. For information on all forms of aviation, educational materials, and films, contact Aviation Education, APA-200.)

Future Aviation Professionals of America (FAPA)
4959 Massachusetts Boulevard
Atlanta, GA 30337
(Firm that helps flight and maintenance workers search for employment)

National Business Aircraft Association, Inc. (NBAA)
1200 18th Street, NW, Suite 200
Washington, DC 20036
(Trade association representing approximately 7,000 companies that own and operate aircraft to enhance business objectives and service and supply business aviation)

Pasco County (Fla.) Summer Course in Model Aeronautics
For more information, write:
Dr. William W. Hendry
Gulf Comprehensive High School
5355 School Road
New Port Richey, FL 34652

Professional Aviation Maintenance Association (PAMA)
500 Northwest Plaza Tower, Suite 401
St. Ann, MO 63074
(Professional (nonunion) association representing aviation maintenance technicians)

Vocational Industrial Clubs of America (VICA)
P.O. Box 3000
Leesburg, VA 22075
(Federation of state associations and local clubs of young people in trade, industrial, technical, and health occupations programs in high schools, vocational schools, and junior and community colleges)

Publications

Aircraft Maintenance: Potential Shortage in National Aircraft Repair Capacity
U.S. General Accounting Office Report to Congressional Requesters, October 1990, Publication GAO/RCED-91-14.
(Copies available from U.S. General Accounting Office, P.O. Box 6015, Gaithersburg, MD 20877, (202) 275-6241)

Aircraft Technician
Johnson Hall Press, Inc.
1233 Janesville Avenue
Fort Atkinson, WI 53538
(Bimonthly magazine for aviation professionals in corporate, commuter, and general aviation)

Aviation Equipment Maintenance
7300 N. Cicero Avenue
Lincolnwood, IL 60646
(Monthly magazine for professionals in aircraft, avionics, and ground-support-equipment maintenance)

Aviation Mechanics Bulletin
Flight Safety Foundation, Inc.
2200 Wilson Boulevard, Suite 500
Arlington, VA 22201
(Bimonthly bulletin of Flight Safety Foundation, Inc., an association of aerospace manufacturers, airlines, insurance companies, schools, and others interested in safety in flight)

PAMA News
500 Northwest Plaza, Suite 401
St. Ann, MO 63074
(Newsletter published ten times per year by the Professional Aviation Maintenance Association (PAMA), covering aviation parts and maintenance as well as association news)

ATEC Journal
2090 Wexford Court
Harrisburg, PA 17112
(Quarterly publication of the Aviation Technician Education Council (ATEC) that provides information on aviation maintenance practice and training)

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